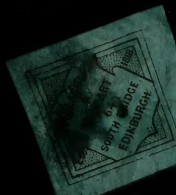


THE
HISTORY OF CREATION

ERNST HAECKEL

E. RAY LANKESTER





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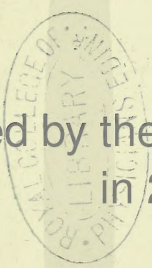
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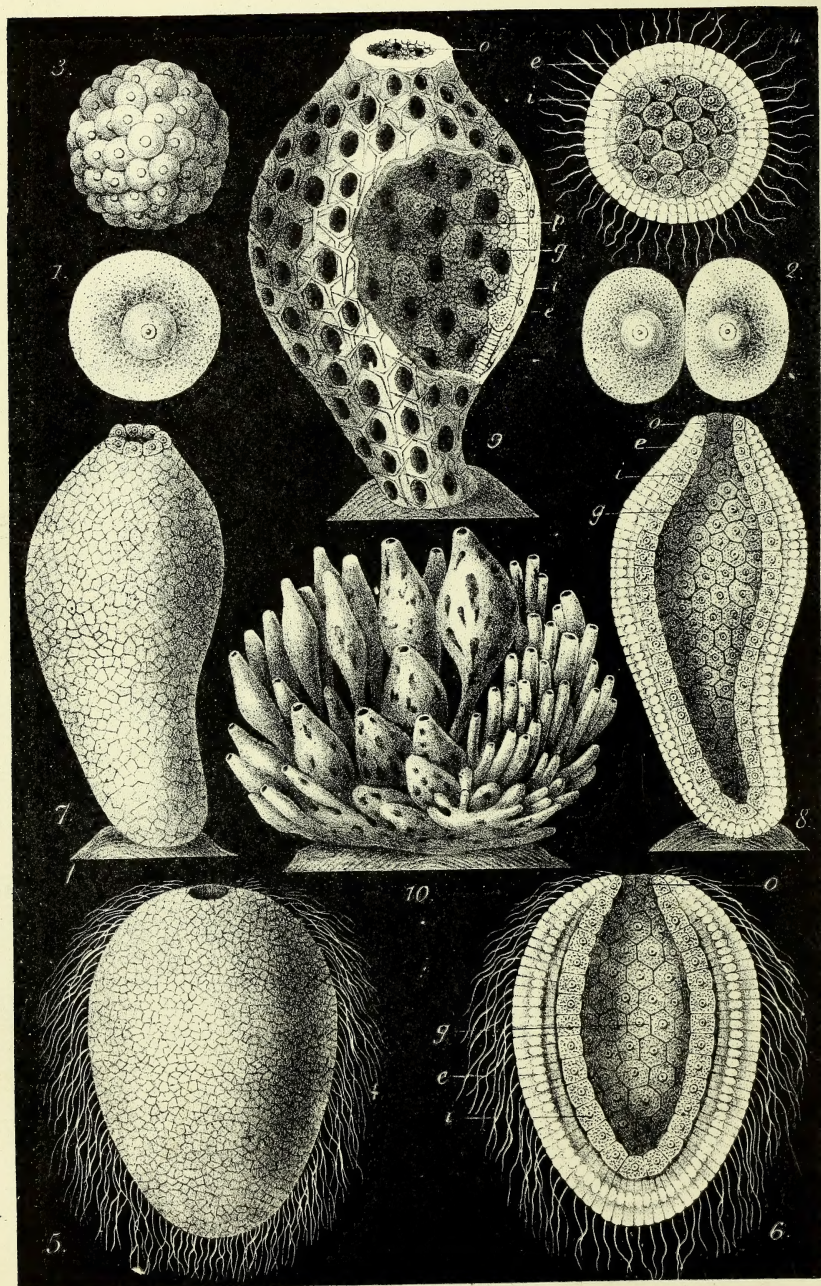
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Development of a Calcareous Sponge (Olynthus)

THE
HISTORY OF CREATION:

*OR THE DEVELOPMENT OF THE EARTH AND ITS
INHABITANTS BY THE ACTION OF NATURAL CAUSES.*

A POPULAR EXPOSITION OF
THE DOCTRINE OF EVOLUTION IN GENERAL, AND OF THAT OF
DARWIN, GOETHE, AND LAMARCK IN PARTICULAR.

FROM THE GERMAN OF
ERNST HAECKEL,
PROFESSOR IN THE UNIVERSITY OF JENA.

THE TRANSLATION REVISED BY
PROFESSOR E. RAY LANKESTER, M.A., F.R.S.,
FELLOW OF EXETER COLLEGE, OXFORD.

IN TWO VOLUMES.

VOL. I.

HENRY S. KING & Co., LONDON.

1876.

A sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man ;
A motion and a spirit that impels
All thinking things, all objects of all thought,
And rolls through all things.

In all things, in all natures, in the stars
Of azure heaven, the unenduring clouds,
In flower and tree, in every pebbly stone
That paves the brooks, the stationary rocks,
The moving waters and the invisible air.

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AUTHOR'S PREFACE TO THE ENGLISH EDITION.

I AM desirous of prefacing the English edition of the "History of Creation" with a few remarks which may serve to explain the origin and object of this book. In the year 1866 I published, under the title "*Generelle Morphologie*," a somewhat comprehensive work, which constituted the first attempt to apply the general doctrine of development to the whole range of organic morphology (Anatomy and Biogenesis), and thus to make use of the vast march onwards which the genius of Charles Darwin has effected in all biological science by his reform of the Descent Theory and its establishment through the doctrine of selection. At the same time, in the "*Generelle Morphologie*," the first attempt was made to introduce the Descent Theory into the systematic classification of animals and plants, and to found a "natural system" on the basis of genealogy; that is, to construct hypothetical pedigrees for the various species of organisms.

The "*Generelle Morphologie*" found but few readers, for which the voluminous and unpopular style of treatment, and its too extensive Greek terminology, may be chiefly to blame. But a proportionately large measure of approval has met

the "Naturliche Schöpfungsgeschichte" in Germany. This book took its origin in the shorthand notes of a course of lectures which treated, before a mixed audience and in a popular form, the most important topics discussed in the "Generelle Morphologie." The notes were subsequently revised, and received considerable additions. The book appeared first in 1868, its fourth edition in 1873, and has been translated into several languages. I hope that it may also find sympathy in the fatherland of Darwin, the more so since it contains special morphological evidence in favour of many of the important doctrines with which this greatest naturalist of our century has enriched science. Proud as England may be to be called the fatherland of Newton, who, with his law of gravitation, brought inorganic nature under the dominion of natural laws of cause and effect, yet may she with even greater pride reckon Charles Darwin among her sons—he who solved the yet harder problem of bringing the complicated phenomena of organic nature under the sway of the same natural laws.

The reproach which is now oftenest made against the Descent Theory is that it is not securely founded, not sufficiently proven. Not only its distinct opponents maintain that there is a want of satisfactory proofs, but even faint-hearted and wavering adherents declare that Darwin's hypothesis is still wanting fundamental proof. Neither the former nor the latter estimate rightly the immeasurable weight which the great series of phenomena of comparative anatomy and ontogeny, palæontology and taxonomy, chorology and oecology, cast into the scale in favour of the doctrine of filiation. Darwin's Theory of Selection, which completely explains the origin of species through the combined action of Inheritance

and Adaptation in the struggle for existence, also appears to these persons not sufficient. They demand, over and above, that the descent of species from common ancestral forms shall be proved in a particular case; that, in contradistinction to the *synthetic* proofs adduced for the Descent Theory, the *analytic* proof of the genealogical continuity of the several species shall be brought forward.

This "analytical solution of the problem of the origin of species" I have myself endeavoured to afford in my recently published "Monograph of the Calcareous Sponges." For five consecutive years I have investigated this small but highly instructive group of animals in all its forms in the most careful manner, and I venture to maintain that the monograph, which is the result of those studies, is the most complete and accurate morphological analysis of an entire organic group which has up to this time been made. Provided with the whole of the material for study as yet brought together, and assisted by numerous contributions from all parts of the world, I was able to work over the whole group of organic forms known as the Calcareous Sponges in that greatest possible degree of fulness which appeared indispensable for the proof of the common origin of its species. This particular animal group is especially fitted for the analytical solution of the species problem, because it presents exceedingly simple conditions of organization, because in it the morphological conditions possess a greatly superior, and the physiological conditions an inferior, import, and because all species of Calcispongiæ are remarkable for the fluidity and plasticity of their form. With a view to these facts, I made two journeys to the sea-coast (1869 to Norway, 1871 to Dalmatia), in order to study as

large a number of individuals as possible in their natural circumstances, and to collect specimens for comparison. Of many species, I compared several hundred individuals in the most careful way. I examined with the microscope and measured in the most accurate manner the details of form of all the species. As the final result of these exhaustive and almost endless examinations and measurements it appeared that "good species," in the ordinary dogmatic sense of the systematists, have no existence at all among the Calcareous Sponges; that the most different forms are connected one with another by numberless gradational transition forms; and that all the different species of Calcareous Sponges are derived from a single exceedingly simple ancestral form, the Olynthus. A drawing of the Olynthus and its earliest stages of development (observe especially the highly important Gastrula) is given in the frontispiece of the present edition. Illustrations of the various structural details which establish the derivation of all Calcareous Sponges from the Olynthus, are given in the atlas of sixty plates which accompanies my monograph of the group. In the gastrula, moreover, is now also found the common ancestral form from which all the tribes of animals (the lowest group, that of the protozoa, alone being excepted) can without difficulty be derived. It is one of the most ancient and important ancestors of the human race!

If we take for the limitation of genus and species an average standard, derived from the actual practice of systematists, and apply this to the whole of the Calcareous Sponges at present known, we can distinguish about twenty-one genera, with one hundred and eleven species (as I have done in the second volume of the Monograph). I have, however, shown that we

may draw up, in addition to this, another systematic arrangement (more nearly agreeing with the arrangement of the *Calcispongiæ* hitherto in vogue) which gives thirty-nine genera and two hundred and eighty-nine species. A systematist who gives a more limited extension to the "ideal species" might arrange the same series of forms in forty-three genera and three hundred and eighty-one species, or even in one hundred and thirteen genera and five hundred and ninety species; another systematist, on the other hand, who takes a wider limit for the abstract "species," would use in arranging the same series of forms only three genera, with twenty-one species, or might even satisfy himself with one genus and seven species. The delimitation of species and genera appears to be so arbitrary a matter, on account of endless varieties and transitional forms in this group, that their number is entirely left to the subjective taste of the individual systematist. In truth, from the point of view of the theory of descent, it appears altogether an unimportant question as to whether we give a wider or a narrower signification to allied groups of forms—whether we choose, that is to say, to call them genera or species, varieties or sub-species. The main fact remains undeniable, viz., the common origin of all the species from one ancestral form. The many-shaped Calcareous Sponges furnish, in the very remarkable conditions of their varieties of aggregation (*metrocomy*), a body of evidence in favour of this view which could hardly be more convincing. Not unfrequently the case occurs of several different forms growing out from a single "stock" or "cormus"—forms which until now have been regarded by systematists, not only as belonging to different species, but even to different genera. Fig. 10 in the frontispiece

represents such a composite stock. This solid and tangible piece of evidence in favour of the common descent of different species ought, one would think, to satisfy the most determined sceptic!

In point of fact, I have a right to expect of my opponents that they shall carefully consider the "exact empirical proof" here brought forward for them, as they have so eagerly demanded. The opponents of the doctrine of filiation, who have too little power of weighing evidence, or possess too little knowledge to appreciate the overpowering weight of proof afforded by the synthetical argument (comparative anatomy, ontogeny, taxonomy, etc.), may yet be able to follow me along the path of analytical proof, and attempt to upset the conclusion as to the common origin of all species of all Calcareous Sponges which I have given in my Monograph. I must, however, repeat that this conclusion is based on the most minute investigation of an extraordinarily rich mass of material,—that it is securely established by thousands of the most careful microscopical observations, measurements, and comparisons of every single part, and that thousands of collected microscopic preparations render, at any moment, the most searching criticism of my results confirmatory of their correctness. One may hope, then, that opponents will endeavour to confront me on the ground of this "exact empiricism," instead of trying to damn my "nature-philosophical speculations." One may hope that they will endeavour to bring forward some evidence to show that the latter do not follow as the legitimate consequences of the former. May they, however, spare me the empty—though by even respectable naturalists oft-repeated—phrase, that the monistic nature-philosophy, as expounded

in the "General Morphology," and in the "History of Creation," is wanting in actual proofs. The proofs are there. Of course those who turn their eyes away from them will not see them. Precisely that "exact" form of analytical proof which the opponents of the descent theory demand is to be found, by anybody who wishes to find it, in the "Monograph of the Calcareous Sponges."

ERNST HEINRICH HAECKEL.

Jena, June 24th, 1873.

NOTE.

FEELING sure that such a book as Professor Haeckel's "Schöpfungsgeschichte" would do a great deal of good, if placed in the hands of the English reading public, and of commencing students of Natural History, I gladly undertook to revise for the publishers the present translation, which was made by a young lady. I have not attempted to escape a difficulty by ignoring the German names made use of by Professor Haeckel for classes, orders, and genera, but have adopted English equivalents. I do not submit these names as a maturely considered English nomenclature, they appear here simply as necessary parts of a close rendering of the German work. I do, however, hold that some such series of English terms is both possible and useful, and do not doubt—in spite of the pretended hostility of the genius of our language, and the curious sentimental objection that English names are *unscientific*—that we shall before long make use of plain English in speaking of the various groups of plants and animals—much to the gain of the larger public, and without detriment to the latinized nomenclature established for the purposes of the professional student.

E. R. L.

Oxford, October, 1874.

THE HISTORY OF CREATION.

CHAPTER I.

NATURE AND IMPORTANCE OF THE DOCTRINE OF FILIIATION, OR DESCENT-THEORY.

General Importance and Essential Nature of the Theory of Descent as reformed by Darwin.—Its Special Importance to Biology (Zoology and Botany).—Its Special Importance to the History of the Natural Development of the Human Race.—The Theory of Descent as the Non-Miraculous History of Creation.—Idea of Creation.—Knowledge and Belief.—History of Creation and History of Development.—The Connection between the History of Individual and Palæontological Development.—The Theory of Purposelessness, or the Science of Rudimentary Organs.—Useless and Superfluous Arrangements in Organisms.—Contrast between the two entirely opposed Views of Nature: the Monistic (mechanical, causal) and the Dualistic (teleological, vital).—Proof of the former by the Theory of Descent.—Unity of Organic and Inorganic Nature, and the Identity of the Active Causes in both.—The Importance of the Theory of Descent to the Monistic Conception of all Nature.

THE intellectual movement to which the impulse was given, thirteen years ago, by the English naturalist, Charles Darwin, in his celebrated work, "On the Origin of Species,"¹ has, within this short period, assumed dimensions which cannot but excite the most universal interest. It is true the scientific theory set forth in that work, which is commonly called briefly Darwinism, is only a small fragment of a far more comprehensive doctrine—a part of the universal

Theory of Development, which embraces in its vast range the whole domain of human knowledge.

But the manner in which Darwin has firmly established the latter by the former is so convincing, and the direction which has been given by the unavoidable conclusions of that theory to all our views of the universe, must appear to every thinking man of such deep significance, that its general importance cannot be over estimated. There is no doubt that this immense extension of our intellectual horizon must be looked upon as by far the most important, and rich in results, among all the numerous and grand advances which natural science has made in our day.

When our century, with justice, is called the age of natural science, when we look with pride upon the immensely important progress made in all its branches, we are generally in the habit of thinking more of immediate practical results, and less of the extension of our general knowledge of nature. We call to mind the complete reform, so infinitely rich in consequences to human intercourse, which has been effected by the development of machinery, by railways, steamships, telegraphs, and other inventions of physics. Or we think of the enormous influence which chemistry has brought to bear upon medicine, agriculture, and upon all arts and trades.

But much as we may value this influence of modern science upon practical life, still it must, estimated from a higher and more general point of view, stand most assuredly below the enormous influence which the theoretical progress of modern science will have on the entire range of human knowledge, on our conception of the universe, and on the perfecting of man's culture.

Think of the immense revolutions in all our theoretical views which we owe to the general application of the microscope. Think of the cell theory, which explains the apparent unity of the human organism as the combined result of the union of a mass of elementary vital units. Or consider the immense extension of our theoretical horizon which we owe to spectral analysis and to the mechanical theory of heat. But among all these wonderful theoretical advances, the theory wrought out by Darwin occupies by far the highest rank.

Every one of my readers has heard of the name of Darwin. But most persons have probably only an imperfect idea of the real value of his theory. If a reader estimates as of equal value all that has been written upon Darwin's memorable work since its appearance, the value of the theory will appear very doubtful to him, supposing that he has not been engaged in the organic natural sciences, and has not penetrated into the inner secrets of zoology and botany. The criticisms of it are so full of contradictions, and for the most part so defective, that we ought not to be at all astonished that even now, after the lapse of thirteen years since the appearance of Darwin's work, it has not gained half that importance which is justly due to it, and which sooner or later it certainly will attain.

Most of the innumerable writings which have been published during these years, both for and against Darwinism, are the productions of persons who are entirely wanting in the necessary amount of biological, and especially of zoological, knowledge. Although almost all of the more celebrated naturalists of the present day are adherents of the theory, yet only a few of them have endeavoured to procure its

acceptance and recognition in larger circles. Hence the odd contradictions and the strange opinions which may still be heard everywhere about Darwinism. This is the reason which induces me to make Darwin's theory, and those further doctrines which are connected with it, the subject of these pages, which, I hope, will be generally intelligible. I hold it to be the duty of naturalists, not merely to meditate upon improvements and discoveries in the narrow circle to which their speciality confines them, not merely to pore over their one study with love and care, but also to seek to make the important general results of it fruitful to the mass, and to assist in spreading the knowledge of physical science among the people. The highest triumph of the human mind, the true knowledge of the most general laws of nature, ought not to remain the private possession of a privileged class of savans, but ought to become the common property of all mankind.

The theory which, through Darwin, has been placed at the head of all our knowledge of nature, is usually called the Doctrine of Filiation, or the Theory of Descent. Others term it the Transmutation Theory. Both designations are correct. For this doctrine affirms, that *all organisms* (viz. all species of animals, all species of plants, which have ever existed or still exist on the earth) *are derived from one single, or from a few simple original forms, and that they have developed themselves from these in the natural course of a gradual change.* Although this theory of development had already been brought forward and defended by several great naturalists, and especially by Lamarek and Goethe, in the beginning of our century, still it was through Darwin, thirteen years ago, that it received its complete demonstration and causal

foundation ; and this is the reason why now it is commonly and exclusively (though not quite correctly) designated as *Darwin's Theory*.

The great and really inestimable value of the Theory of Descent appears in a different light, accordingly as we merely consider its more immediate connection with organic natural science, or its larger influence upon the whole range of man's knowledge of the universe. Organic natural science, or Biology, which as Zoology treats of animals, as Botany of plants, is completely reformed and founded anew by the Theory of Descent. For by this theory we are made acquainted with the active causes of organic forms, while up to the present time Zoology and Botany have simply been occupied with the facts of these forms. We may therefore also term the theory of descent a *mechanical explanation of organic forms*, or the science of the true causes of Organic Nature.

As I cannot take for granted that my readers are all familiar with the terms "organic and inorganic nature," and as the contrast of both these natural bodies will, in future, occupy much of our attention, I must say a few words in explanation of them. We designate as *Organisms*, or *Organic bodies*, all *living creatures* or *animated bodies*; therefore all plants and animals, man included; for in them we can almost always prove a combination of various parts (instruments or organs) which work together for the purpose of producing the phenomena of life. Such a combination we do not find in *Anorgana*, or inorganic natural bodies—the so-called dead or *inanimate bodies*, such as minerals or stones, water, the atmospheric air, etc. Organisms always contain albuminous combinations of carbon in a semi-fluid

condition of aggregation, which are always wanting in the Anorgana. Upon this important distinction rests the division of all natural history into two great and principal parts—*Biology*, or the science of Organisms (Zoology and Botany), and *Anorganology*, or the science of Anorgana (Mineralogy, Geology, Meteorology, etc.).

The great value of the Theory of Descent in regard to Biology consists, as I have already remarked, in its explaining to us the origin of organic forms in a mechanical way, and pointing out their active causes. But however highly and justly this service of the Theory of Descent may be valued, yet it is almost eclipsed by the immense importance which a single necessary inference from it claims for itself alone. This necessary and unavoidable inference is the theory of the *animal descent of the human race*.

The determination of the position of man in nature, and of his relations to the totality of things—this question of all questions for mankind, as Huxley justly calls it—is finally solved by the knowledge that man is descended from animals. In consequence of Darwin's reformed Theory of Descent, we are now in a position to establish scientifically the groundwork of a *non-miraculous history of the development of the human race*. All those who have defended Darwin's theory, as well as all its thoughtful opponents, have acknowledged that, as a matter of necessity, it follows from his theory that the human race, in the first place, must be traced to ape-like mammals, and further back to the lower vertebrate animals.

It is true Darwin himself did not express at first this most important of all the inferences from his theory. In his work, "On the Origin of Species," not a word is found

about the animal descent of man. The courageous but cautious naturalist was at that time purposely silent on the subject, for he anticipated that this most important of all the conclusions of the Theory of Descent was at the same time the greatest obstacle to its being generally accepted and acknowledged. Certain it is that Darwin's book would have created, from the beginning, even much more opposition and offence, if this most important inference had at once been clearly expressed. It was not till twelve years later, in his work on "The Descent of Man, and Selection in Relation to Sex," that Darwin openly acknowledged that far-reaching conclusion, and expressly declared his entire agreement with those naturalists who had, in the meantime, themselves formed that conclusion. Manifestly the effect of this conclusion is immense, and *no* science will be able to escape from the consequences. Anthropology, or the science of man, and consequently all philosophy, are thereby thoroughly reformed in all their various branches.

It will be a later task in these pages to discuss this special point. I shall not treat of the theory of the animal descent of man till I have spoken of Darwin's theory, and its general foundation and importance. To express it in one word, that most important, but (to most men) at first repulsive, conclusion is nothing more than a special deduction, which we must draw from the general inductive law of the descent theory (now firmly established), according to the stern commands of inexorable logic.

Perhaps nothing will make the full meaning of the theory of descent clearer than calling it "the *non-miraculous history of creation*." I have therefore chosen that name for this work. It is, however, correct only in a certain

sense, and it must be borne in mind that, strictly speaking, the expression "non-miraculous history of creation" contains a "*contradictio in adjecto*."

In order to understand this, let us for a moment examine somewhat more closely what we understand by *creation*. If we understand the creation to mean the *coming into existence of a body* by a creative power or force, we may then either think of the *coming into existence of its substance* (corporeal matter), or of the *coming into existence of its form* (the corporeal form).

Creation in the former sense, as the *coming into existence of matter*, does not concern us here at all. This process, if indeed it ever took place, is completely beyond human comprehension, and can therefore never become a subject of scientific inquiry. Natural science teaches that matter is eternal and imperishable, for experience has never shown us that even the smallest particle of matter has come into existence or passed away. Where a natural body seems to disappear, as for example by burning, decaying, evaporation, etc., it merely changes its form, its physical composition or chemical combination. In like manner the coming into existence of a natural body, for example, of a crystal, a fungus, an infusorium, depends merely upon the different particles, which had before existed in a certain form or combination, assuming a new form or combination in consequence of changed conditions of existence. But never yet has an instance been observed of even the smallest particle of matter having vanished, or even of an atom being added to the already existing mass. Hence a naturalist can no more imagine the coming into existence of matter, than he can imagine its disappearance, and he therefore looks upon

the existing quantity of matter in the universe as a given fact. If any person feels the necessity of conceiving the coming into existence of this matter as the work of a supernatural creative power, of the creative force of something outside of matter, we have nothing to say against it. But we must remark, that thereby not even the smallest advantage is gained for a scientific knowledge of nature. Such a conception of an immaterial force, which at the first creates matter, is an article of faith which has nothing whatever to do with human science. *Where faith commences, science ends.* Both these arts of the human mind must be strictly kept apart from each other. Faith has its origin in the poetic imagination; knowledge, on the other hand, originates in the reasoning intelligence of man. Science has to pluck the blessed fruits from the tree of knowledge, unconcerned whether these conquests trench upon the poetical imaginings of faith or not.

If, therefore, science makes the "history of creation" its highest, most difficult, and most comprehensive problem, it must accept as its idea of creation the second explanation of the word, viz. *the coming into being of the form of natural bodies.* In this way geology, which tries to investigate the origin of the inorganic surface of the earth as it now appears, and the manifold historical changes in the form of the solid crust of the earth, may be called the history of the creation of the earth. In like manner, the history of the development of animals and plants, which investigates the origin of living forms, and the manifold historical changes in animal and vegetable forms, may be termed the history of the creation of organisms. As, however, in the idea of creation, although used in this sense, the

unscientific idea of a creator existing outside of matter, and changing it, may easily creep in, it will perhaps be better in future to substitute for it the more accurate term, *development*.

The great value which the *History of Development* possesses for the scientific understanding of animal and vegetable forms, has now been generally acknowledged for many years, and without it it would be impossible to make any sure progress in organic morphology, or the theory of forms. But by the history of development, only one part of this science has generally been understood, namely, that of organic individuals, usually called Embryology, but more correctly and comprehensively, *Ontogeny*. But, besides this, there is another history of development of organic species, genera, and tribes (phyla), which has the most important relations to the former.

The subject of this is furnished to us by the science of petrifications, or palæontology, which shows us that each tribe of animals and plants, during different periods of the earth's history, has been represented by a series of entirely different genera and species. Thus, for example, the tribe of vertebrated animals was represented by classes of fish, amphibious animals, reptiles, birds, and mammals, and each of these groups, at different periods, by quite different kinds. This palæontological history of the development of organisms, which we may term *Phylogeny*, stands in the most important and remarkable relation to the other branch of organic history of development, I mean that of individuals, or *Ontogeny*. On the whole, the one runs parallel to the other. In fact, the history of individual development, or *Ontogeny*, is a short and quick recapitulation of palæonto-

logical development, or Phylogeny, dependent on the laws of Inheritance and Adaptation.

As I shall have, later, to explain this most interesting and important coincidence more fully, I shall not dwell further upon it here, and merely call attention to the fact that it can only be explained and its causes understood by the Theory of Descent, while without that theory it remains completely incomprehensible and inexplicable. The Theory of Descent in the same way shows us *why* individual animals and plants must develop at all, and why they do not come into life at once in a perfect and developed state. No supernatural history of creation can in any way explain to us the great mystery of organic development. To this most weighty question, as well as to all other biological questions, the Theory of Descent gives us perfectly satisfactory answers—and always answers which refer to purely mechanical causes, and point to purely physico-chemical forces as the causes of phenomena which we were formerly accustomed to ascribe to the direct action of supernatural, creative forces. Hence, by our theory the mystic veil of the miraculous and supernatural, which has hitherto been allowed to hide the complicated phenomena of this branch of natural knowledge, is removed. All the departments of Botany and Zoology, and especially the most important portion of the latter, Anthropology, become reasonable. The dimming mirage of mythological fiction can no longer exist in the clear sunlight of scientific knowledge.

Of special interest among general biological phenomena are those which are quite irreconcilable with the usual supposition, that every organism is the product of a creative power, acting for a definite object. Nothing in this respect

caused the earlier naturalists greater difficulty than the explanation of the so-called "*rudimentary organs*,"—those parts in animal and vegetable bodies which really have no function, which have no physiological importance, and yet exist in form. These parts deserve the most careful attention, although most unscientific men know little or nothing about them. Almost every organism, almost every animal and plant possesses, besides the obviously useful arrangements of its organization, other arrangements the purpose of which it is utterly impossible to make out.

Examples of this are found everywhere. In the embryos of many ruminating animals—among others, in our common cattle—fore-teeth, or incisors, are placed in the mid-bone of the upper jaw, which never fully develop, and therefore serve no purpose. The embryos of many whales—which afterwards possess the well-known whalebone instead of teeth, yet have before they are born, and while they take no nourishment, teeth in their jaws, which set of teeth never comes into use. Moreover, most of the higher animals possess muscles which are never employed; even man has such rudimentary muscles. Most of us are incapable of moving our ears as we wish, although the muscles for this movement exist, and although individual persons who have taken the trouble to exercise these muscles do succeed in moving their ears. It is still possible, by special exercise, by the persevering influence of the will upon the nervous system, to reanimate the almost extinct activity in the existing but imperfect organs, which are on the road to complete disappearance. On the other hand, we can no longer do this with another set of small rudimentary muscles, which still exist in the cartilage of the outer ear,

but which are always perfectly inactive. Our long-eared ancestors of the tertiary period—apes, semi-apes, and pouched animals, like most other mammals, moved their large ear-flaps freely and actively; their muscles were much more strongly developed and of great importance. In a similar way, many varieties of dogs and rabbits, under the influence of civilized life, have left off “pricking up” their ears, and thereby have acquired imperfect auricular muscles and loose-hanging ears, although their wild ancestors moved their stiff ears in many ways.

Man has also these rudimentary organs on other parts of his body; they are of no importance to life, and never perform any function. One of the most remarkable, although the smallest organ of this kind, is the little crescent-like fold, the so-called “*plica semilunaris*,” which we have in the inner corner of the eye, near the root of the nose. This insignificant fold of skin, which is quite useless to our eye, is the imperfect remnant of a third inner eyelid which, besides the upper and under eyelid, is highly developed in other mammals, and in birds and reptiles. Even our very remote ancestors of the Silurian period, the Primitive Fishes, seem to have possessed this third eyelid, the so-called nictitating membrane. For many of their nearest kin, who still exist in our day but little changed in form, viz. many sharks, possess a very strong nictitating membrane, which they can draw right across the whole eyeball, from the inner corner of the eye.

Eyes which do not see form the most striking example of rudimentary organs. These are found in very many animals, which live in the dark, as in caves or underground. Their eyes often exist in a well-developed condition, but they are

covered by membrane, so that no ray of light can enter, and they can never see. Such eyes, without the function of sight, are found in several species of moles and mice which live underground, in serpents and lizards, in amphibious animals (*Proteus*, *Cæcilia*), and in fishes; also in numerous invertebrate animals, which pass their lives in the dark, as do many beetles, crabs, snails, worms, etc.

An abundance of the most interesting examples of rudimentary organs is furnished by Comparative Osteology, or the study of the skeletons of vertebrate animals, one of the most attractive branches of Comparative Anatomy. In most of the vertebrate animals we find two pairs of limbs on the body, a pair of fore-legs and a pair of hind-legs. Very often, however, one or the other pair is imperfect; it is seldom that both are, as in the case of serpents and some varieties of eel-like fish. But some serpents, viz. the giant serpents (*Boa*, *Python*), have still in the hinder portion of the body some useless little bones, which are the remains of lost hind-legs.

In like manner the mammals of the whale tribe (*Cetacea*), which have only fore-legs fully developed (breast-fins), have further back in their body another pair of utterly superfluous bones, which are remnants of undeveloped hind-legs. The same thing occurs in many genuine fishes, in which the hind-legs have in like manner been lost.

Again, in our slow-worm (*Anguis*), and in some other lizards, no fore-legs exist, although they have a perfect shoulder apparatus within their bodies, which should serve as a means of affixing the legs. Moreover, in various vertebrate animals, the single bones of both pairs of legs are found in all the different stages of imperfection, and often the degenerate bones and those muscles belonging to them

are partially preserved, without their being able in any way to perform any function. The instrument is still there, but it can no longer play.

Moreover, we can, almost as generally, find rudimentary organs in the blossoms of plants, inasmuch as one part or another of the male organs of propagation—the stamen and anther, or of the female organs of propagation—the style, germ, etc.—is more or less imperfect or abortive. Among these we can trace, in various closely connected species of plants, the organ in all stages of degeneration. Thus, for example, the great natural family of lip-blossomed plants (*Labiatae*), to which the balm, peppermint, marjoram, ground-ivy, thyme, etc., belong, are distinguished by the fact that their mouth-like, two-lipped flower contains two long and two short stamens. But in many exceptional plants of this family, *e. g.* in different species of sage, and in the rosemary, only one pair of stamens is developed; the other pair is more or less imperfect, or has quite disappeared. Sometimes stamens exist, but without the anthers, so that they are utterly useless. Less frequently the rudiment or imperfect remnant of a fifth stamen is found, physiologically (for the functions of life) quite useless, but morphologically (for the knowledge of the form and of the natural relationship) a most valuable organ. In my “General Morphology of Organisms,”⁴ in the chapter on “Purposelessness, or Dysteleology,” I have given a great number of other examples (*Gen. Morph.* ii. 226).

No biological phenomenon has perhaps ever placed zoologists or botanists in greater embarrassment than these rudimentary or abortive organs. They are instruments without employment, parts of the body which exist without

performing any service—adapted for a purpose, but without in reality fulfilling that purpose. When we consider the attempts which the earlier naturalists have made in order to explain this mystery, we can scarcely help smiling at the strange ideas to which they were led. Being unable to find a true explanation, they came, for example, to the conclusion that the Creator had placed these organs there “for the sake of symmetry,” or they believed that it had appeared unwise and unsuitable to the Creator (seeing that their nearest kin did possess such organs) that these organs should be completely wanting in creatures, where they are incapable of performing a function, and where it cannot be otherwise from the special mode of life. In compensation for the non-existing function, he had at least furnished them with the outward but empty form; nearly in the same manner as civil officers, in uniform, are furnished with an innocent sword, which is never drawn from the scabbard. I scarcely believe, however, that any of my readers will be content with such an explanation.

Now, it is precisely this widely spread and mysterious phenomenon of rudimentary organs, in regard to which all other attempts at explanation fail, which is perfectly explained, and indeed in the simplest and clearest way, by Darwin's *Theory of Inheritance and Adaptation*. We can trace the important laws of inheritance and adaptation in the domestic animals which we breed, and the plants which we cultivate; and a series of such laws of inheritance have already been established. Without going further into this at present, I will only remark that some of them perfectly explain, in a mechanical way, the coming into existence of rudimentary organs, so that we must look upon the appear-

ance of such structures as an entirely natural process, arising from the *disuse of the organs*.

By *adaptation* to special conditions of life, the formerly active and really working organs have gradually ceased to be used or employed. In consequence of their not being exercised they have become more and more imperfect, but in spite of this have always been handed down from one generation to another by *inheritance*, until at last they vanish partially or entirely. Now, if we admit that all the vertebrate animals mentioned above are derived from one common ancestor, possessing two seeing eyes and two well developed pairs of legs, the different stages of suppression and degeneration of these organs are easily accounted for in such of the descendants as could no longer use them. In like manner the various stages of suppression of the stamens, originally existing to the number of five (in the flower-bud), among the Labiatae is explained, if we admit that all the plants of this family sprung from one common ancestor, provided with five stamens.

I have here spoken somewhat fully of the phenomena of rudimentary organs, because they are of the utmost general importance, and because they lead us to the great, general, and fundamental questions in philosophy and natural science, for the solution of which the Theory of Descent has now become the indispensable guide. As soon, in fact, as, according to this theory, we acknowledge the exclusive activity of physico-chemical causes in living (organic) bodies, as well as in so-called inanimate (inorganic) nature, we concede exclusive dominion to that view of the universe, which we may designate as the *mechanical*, and which is opposed to the *teleological* conception. If we

compare all the ideas of the universe prevalent among different nations at different times, we can divide them all into two sharply contrasted groups—a *causal* or *mechanical*, and a *teleological* or *vitalistic*. The latter has prevailed generally in Biology until now, and accordingly the animal and vegetable kingdoms have been considered as the products of a creative power, acting for a definite purpose. In the contemplation of every organism the unavoidable conviction seemed to press itself upon us, that such a wonderful machine, so complicated an apparatus for motion as exists in the organism, could only be produced by a power analogous to, but infinitely more perfect than, the power of man in the construction of his machines.

However sublime the former idea of a Creator, and his creative power, may have been; however much it may be attempted to divest it of all human analogy, yet in the end this analogy still remains unavoidable and necessary in the teleological conception of nature. In reality the Creator must himself be conceived of as an organism, that is, as a being who, analogous to man, even though in an infinitely more perfect form, reflects on his constructive power, lays down a plan of his mechanisms, and then, by the application of suitable materials, makes them answer their purpose. Such conceptions necessarily suffer from the fundamental error of *anthropomorphism*, or man-likening. In such a view, however exalted the Creator may be imagined, we assign to him the human attributes of designing a plan, and therefrom suitably constructing the organism. This is, in fact, quite clearly expressed in that view which is most sharply opposed to Darwin's theory, and which has found among naturalists its most distinguished representative in

Agassiz. His celebrated work, "An Essay on Classification,"⁵ which is entirely opposed to Darwin's, and appeared almost at the same time, has elaborated quite consistently, and to the utmost extent, these anthropomorphic conceptions of the Creator.

I maintain with regard to the much-talked-of "purpose in nature," that it really has no existence but for those persons who observe phenomena in animals and plants in the most superficial manner. Without going more deeply into the matter, we can see at once that the rudimentary organs are a formidable obstacle to this theory. And, indeed, every one who makes a really close study of the organization and mode of life of the various animals and plants, and becomes familiar with the reciprocity or inter-action of the phenomena of life, and the so-called "economy of nature," must necessarily come to the conclusion that this "purposiveness" no more exists than the much-talked-of "beneficence" of the Creator. These optimistic views have, unfortunately, as little real foundation as the favourite phrase, the "moral order of the universe," which is illustrated in an ironical way by the history of all nations. The dominion of the "moral" popes, and their pious inquisition, in the mediæval times, is not less significant of this than the present prevailing militarism, with its "moral" apparatus of needle-guns and other refined instruments of murder.

If we contemplate the common life and the mutual relations between plants and animals (man included), we shall find everywhere, and at all times, the very opposite of that kindly and peaceful social life which the goodness of the Creator ought to have prepared for his creatures—we shall

rather find everywhere a pitiless, most embittered *Struggle of All against All*. Nowhere in nature, no matter where we turn our eyes, does that idyllic peace, celebrated by the poets, exist; we find everywhere a struggle and a striving to annihilate neighbours and competitors. Passion and selfishness—conscious or unconscious—is everywhere the motive force of life. The well-known words of the German poet—

“Die Welt ist vollkommen überall
Wo der Mensch nicht hinkommt mit seiner Qual.” *

are beautiful, but, unfortunately, not true. Man in this respect certainly forms no exception to the rest of the animal world. The remarks which we shall have to make on the theory of “Struggle for Existence” will sufficiently justify this assertion. It is, in fact, Darwin who has placed this important point, in its high and general significance, very clearly before our eyes, and the chapter in his theory which he himself calls “Struggle for Existence” is one of the most important parts of it.

Whilst, then, we emphatically oppose the vital or teleological view of animate nature which presents animal and vegetable forms as the productions of a kind Creator, acting for a definite purpose, or of a creative, natural force acting for a definite purpose, we must, on the other hand, decidedly adopt that view of the universe which is called the *mechanical* or *causal*. It may also be called the *monistic*, or *single-principle* theory, as opposed to the *two-fold principle*, or *dualistic* theory, which is necessarily implied in the teleological conception of the universe. The

* The world is perfect save where Man
Comes in with his strife.

mechanical view of nature has for many years been so firmly established in certain domains of natural science, that it is here unnecessary to say much about it. It no longer occurs to physicists, chemists, mineralogists, or astronomers, to seek to find in the phenomena which continually appear before them in their scientific domain the action of a Creator acting for a definite purpose. They universally, and without hesitation, look upon the phenomena which appear in their different departments of study as the necessary and invariable effects of physical and chemical forces which are inherent in matter. Thus far their view is purely *materialistic*, in a certain sense of that "word of many meanings."

When a physicist traces the phenomena of motion in electricity or magnetism, the fall of a heavy body, or the undulations in the waves of light, he never, in the whole course of his research, thinks of looking for the interference of a supernatural power. In this respect, Biology, as the science of so-called "*animated*" natural bodies, was formerly placed in sharp opposition to the above-mentioned inorganic natural sciences (Anorganology). It is true modern Physiology, the science of the phenomena of motion in animals and plants, has completely adopted the mechanical view; but Morphology, the science of the forms of animals and plants, has not been affected at all by it. Morphologists, in spite of the position of physiology, have continued, as before, in opposition to the mechanical view of functions, to look upon the forms of animals and plants as something which cannot be at all explained mechanically, but which must owe its origin necessarily to a higher, supernatural creative power, acting for a definite purpose.

In this general view it is quite indifferent whether the

creative power be worshipped as a personal god, or whether it be termed the power of life (*vis vitalis*), or final cause (*causa finalis*). In any case, to express it in one word, its supporters have recourse to a *miracle* for an explanation. They throw themselves into the arms of a poetic faith, which as such can have no value in the domain of scientific knowledge.

All that was done before Darwin, to establish a natural mechanical conception of the origin of animals and plants, has been in vain, and until his time no theory gained a general recognition. Darwin's theory first succeeded in doing this, and thus has rendered an immense service. For the idea of the *unity of organic and inorganic nature* is now firmly established; and that branch of natural science which had longest and most obstinately opposed mechanical conception and explanation, viz. the science of the structure of animate forms, is launched on to identically the same road towards perfection as that along which all the rest of the natural sciences are travelling. The unity of *all* natural phenomena is by Darwin's theory finally established.

This unity of all nature, the animating of all matter, the inseparability of mental power and corporeal substance, Goethe has asserted in the words: "Matter can never exist and be active without mind, nor can mind without matter." These first principles of the mechanical conception of the universe have been taught by the great monistic philosophers of all ages. Even Democritus of Abdera, the immortal founder of the Atomic theory, clearly expressed them about 500 years before Christ; but the great Dominican friar, Giordano Bruno, did so even more explicitly. For this he was burnt at the stake, by the Christian inquisition in

Rome, on the 17th of Feb., 1600, on the same day on which, 36 years before, Galileo, his great fellow-countryman and fellow-worker, was born. Such men, who live and die for a great idea, are usually stigmatized as "materialists"; but their opponents, whose arguments were torture and the stake, are praised as "spiritualists."

By the Theory of Descent we are for the first time enabled to conceive of the unity of nature in such a manner that a mechanico-causal explanation of even the most intricate organic phenomena, for example, the origin and structure of the organs of sense, is no more difficult (in a general way) than is the mechanical explanation of any physical process; as, for example, earthquakes, the courses of the wind, or the currents of the ocean. We thus arrive at the extremely important conviction that *all natural bodies* which are known to us are *equally animated*, that the distinction which has been made between animate and inanimate bodies does *not* exist. When a stone is thrown into the air, and falls to earth according to definite laws, or when in a solution of salt a crystal is formed, the phenomenon is neither more nor less a mechanical manifestation of life than the growth and flowering of plants, than the propagation of animals or the activity of their senses, than the perception or the formation of thought in man. This final triumph of the monistic conception of nature constitutes the highest and most general merit of the Theory of Descent, as reformed by Darwin.

CHAPTER II.

SCIENTIFIC JUSTIFICATION OF THE THEORY OF DESCENT. HISTORY OF CREATION ACCORDING TO LINNÆUS.

The Theory of Descent, or Doctrine of Filiation, as the Monistic Explanation of Organic Natural Phenomena.—Its Comparison with Newton's Theory of Gravitation.—Limits of Scientific Explanation and of Human Knowledge in general.—All Knowledge founded originally on Sensuous Experience, *à posteriori*.—Transition of *à posteriori* knowledge, by Inheritance, into *à priori* knowledge.—Contrast between the Supernatural Hypotheses of the Creation according to Linnæus, Cuvier, Agassiz, and the Natural Theories of Development according to Lamarck, Goethe, and Darwin.—Connection of the former with the Monistic (mechanical), of the latter with the Dualistic Conception of the Universe.—Monism and Materialism.—Scientific and Moral Materialism.—The History of Creation according to Moses.—Linnæus as the Founder of the Systematic Description of Nature and Distinction of Species.—Linnæus' Classification and Binary Nomenclature.—Meaning of Linnæus' Idea of Species.—His History of Creation.—Linnæus' view of the Origin of Species.

THE value which every scientific theory possesses is measured by the number and importance of the objects which can be explained by it, as well as by the simplicity and universality of the causes which are employed in it as grounds of explanation. On the one hand, the greater the number and the more important the meaning of the phenomena explained by the theory, and the simpler, on the other hand, and the more general the causes which the theory assigns as explanations, the greater is its scientific

value, the more safely we are guided by it, and the more strongly are we bound to adopt it.

Let us call to mind, for example, that theory which has ranked up to the present time as the greatest achievement of the human mind—the Theory of Gravitation, which Newton, two hundred years ago, established in his Mathematical Principles of Natural Philosophy. Here we find that the object to be explained is as large as one can well imagine. He undertook to reduce the phenomena of the motion of the planets, and the structure of the universe, to mathematical laws. As the most simple cause of these intricate phenomena of motion, Newton established the law of weight or attraction, the same law which is the cause of the fall of bodies, of adhesion, cohesion, and many other phenomena.

If we apply the same standard of valuation to Darwin's theory, we must arrive at the conclusion that this theory, also, is one of the greatest achievements of the human mind, and that it may be placed quite on a level with Newton's Theory of Gravitation. Perhaps this opinion will seem a little exaggerated, or at any rate very bold, but I hope in the course of this treatise to convince the reader that this estimate is not too high. In the preceding chapter, some of the most important and most general phenomena in organic nature, which have been explained by Darwin's theory, have been named. Among them are the variations in form which accompany the individual development of organisms, most varied and complicated phenomena, which until now presented the greatest difficulties in the way of mechanical explanation, that is, in the tracing of them to active causes. We have mentioned the *rudimen-*

tary organs, those exceedingly remarkable structures in animals and plants which have no object and refute every teleological explanation seeking for the final purpose of the organism. A great number of other phenomena might have been mentioned, which are no less important, and are explained in the simplest manner by Darwin's reformed Theory of Descent. For the present I will only mention the phenomena presented to us by the *geographical distribution of animals and plants* on the surface of our planet, as well as the *geological distribution of the extinct and petrified organisms* in the different strata of the earth's crust. These important palæontological and geographical phenomena, which were formerly only known to us as *facts*, are now traced to their active *causes* by the Theory of Descent.

The same statement applies further to all the general laws of *Comparative Anatomy*, especially to the great law of *division of labour* or *separation* (polymorphism, or differentiation), a law which determines the form or structure of human society, as well as the organization of individual animals and plants. It is this law which necessitates an ever *increasing variety*, as well as a *progressive development* of organic forms. This law of the division of labour has, up to the present time, been only recognized as a fact, and it, like the law of progressive development, or the law of progress which we perceive active everywhere in the history of nations (as also in that of animals and plants), is explained by Darwin's Doctrine of Descent. Then, if we turn our attention to the great whole of organic nature, if we compare all the individual groups of phenomena of this immense domain of life, it cannot fail to appear, in the light

of the Doctrine of Descent, no longer as the ingeniously designed work of a Creator building up according to a definite purpose, but as the necessary consequence of active causes, which are inherent in the chemical combination of matter itself, and in its physical properties.

In fact, we can most positively assert, and I shall justify this assertion in the course of these pages, that by the Doctrine of Filiation, or Descent, we are enabled for the first time to reduce all organic phenomena to a single law, and to discover a single active cause for the infinitely intricate mechanism of the whole of this rich world of phenomena. In this respect, Darwin's theory stands quite on a level with Newton's Theory of Gravitation; indeed, it even rises higher than Newton's theory!

The grounds of explanation are equally simple in the two theories. In explaining this most intricate world of phenomena, Darwin does not make use of new or hitherto unknown properties of matter, nor does he, as one might suppose, make use of discoveries of new combinations of matter or of new forces of organization; but it is simply by extremely ingenious combination, by the synthetic comprehension, and by the thoughtful comparison of a number of well-known facts, that Darwin has solved the "holy mystery" of the living world of forms. The consideration of the interchanging relations which exist between two general properties of organisms, viz. *Inheritance and Adaptation*, is what has here been of the first importance. Merely by considering the relations between these two vital actions or physiological functions of organisms, also further by considering the reciprocal inter-action which all animals and plants, living in one and the same

place, necessarily exert on one another—solely by the correct estimate of these simple facts, and by skilfully combining them, Darwin has succeeded in finding the true active causes (*causæ efficientes*) of the immensely intricate world of forms in organic nature.

In any case we are in duty bound to accept this theory till a better one be found, which will undertake to explain the same amount of facts in an equally simple manner. Until now we have been in utter want of such a theory. The fundamental idea that all different animal and vegetable forms must be descended from a few or even from one single, most simple primary form, was indeed not new. This idea was long since distinctly formulated—first by the great Lamarck, at the beginning of our century. But Lamarck in reality only expressed the hypothesis of the Doctrine of Filiation, without establishing it by an explanation of the active causes. And it is just the demonstration of these causes which marks the extraordinary progress which Darwin's theory has made beyond that of Lamarck. In the physiological properties of Inheritance and Adaptation of organic matter, Darwin discovered the true cause of the genealogical relationship of organisms. It was not possible for the genius of Lamarck in his day to command that colossal material of biological facts which has been collected by the patient zoological and botanical investigations of the last fifty years, and which has been used by Darwin as an overpowering apparatus of evidence.

Darwin's theory is therefore not what his opponents frequently represent it as being—an unwarranted hypothesis taken up at random. It is not for zoologists or botanists to accept or reject this as an explanatory theory, as they

please ; they are rather compelled and obliged to accept it, according to the general principle observed in all natural sciences, that we must accept and retain for the explanation of phenomena any theory which, though it has only a feeble basis, is compatible with the actual facts—until it is replaced by a better one. If we do not adopt it, we renounce a scientific explanation of phenomena, and this is, in fact, the position which many biologists still maintain. They look upon the whole domain of animate nature as a perfect mystery, and upon the origin of animals and plants, the phenomena of their development and affinities, as quite inexplicable and miraculous; in fact, they will not allow that there *can* be a true understanding of them.

Those opponents of Darwin who do not exactly wish to renounce a scientific explanation are in the habit of saying, “Darwin’s theory of the common origin of the different species is only *one* hypothesis; we oppose to it *another*, the hypothesis that the individual animal and vegetable species have not developed one from another by descent, but that they have come into existence independently of one another, by a still undiscovered law of nature.” But as long as it is not shown how this coming into existence is to be conceived of, and what that “law of nature” is—as long as not even *probable* grounds of explanation can be brought forward to account for the independent coming into existence of animal and vegetable species, so long this counter-hypothesis is in fact no hypothesis, but an empty unmeaning phrase. Darwin’s theory ought, moreover, not to be called an hypothesis. For a scientific hypothesis is a supposition, postulating the existence of unknown properties or motional phenomena of natural bodies, which

properties have not as yet been observed by the experience of the senses. But Darwin's theory does not assume such unknown conditions; it is based upon general properties of organisms that have long been recognized, and—as has been remarked—it is the exceedingly ingenious and comprehensive combination of a number of phenomena which had hitherto stood isolated, which gives the theory its extraordinarily great and intrinsic value. By it we are for the first time in a position to demonstrate an active cause for all the known morphological phenomena in the animal and vegetable kingdoms; and, in fact, this cause is always one and the same, viz. the alternate action of Adaptation and Inheritance, therefore a physiological, that is, a physico-chemical or mechanical, relationship. For these reasons the acceptance of the Doctrine of Filiation, as mechanically established by Darwin, is a binding and unavoidable necessity for the whole domain of zoology and botany.

As, therefore, in my opinion the immense importance of Darwin's theory lies in the fact that it has *mechanically explained those organic phenomena of forms* which had hitherto been unexplained, it is perhaps necessary that I should here say a few words about the different ideas connected with the word "explanation." It is very frequently said, in opposition to Darwin's theory, that it does indeed explain those phenomena by Inheritance and Adaptation, but that it does not at the same time explain those properties of organic matter, and that therefore we do not arrive at first causes. This objection is quite correct, but it applies equally to *all* explanations of phenomena. We *nowhere* arrive at a knowledge of first causes. The origin of

every simple salt crystal, which we obtain by evaporating its mother liquor, is no less mysterious to us, as far as concerns its first cause, and in itself no less incomprehensible than the origin of every animal which is developed out of a simple cell. In explaining the most simple physical or chemical phenomena, as the falling of a stone, or the formation of a chemical combination, we arrive, by discovering and establishing the active causes—for example, the gravitation or the chemical affinity—at other remoter phenomena, which in themselves are mysterious. This arises from the limitation or relativity of our powers of understanding. We must not forget that human knowledge is absolutely limited, and possesses only a relative extension. It is, in its essence, limited by the very nature of our senses and of our brains.

All knowledge springs from sensuous perceptions. In opposition to this statement, the innate, *à priori* knowledge of man may be brought up; but we can see that the so-called *à priori* knowledge can by Darwin's theory be proved to have been acquired *à posteriori*, being based on experience as its first cause. Knowledge which is based originally upon purely empirical observations, and which is therefore a purely sensuous experience, but has then been transmitted from generation to generation by inheritance, appears in later generations as if it were independent, innate, and *à priori*. In our late animal ancestors, all our so-called "*à priori* knowledge" was originally acquired *à posteriori*, and only gradually became *à priori* by inheritance. It is based in the first instance upon experiences, and by the laws of Inheritance and Adaptation we can positively prove that knowledge *à priori* and knowledge *à*

posteriori cannot rightly be placed in opposition, as is usually done. On the contrary, sensuous experience is the original source of *all* knowledge. For this reason alone, all our knowledge is limited, and we can never apprehend the *first causes* of any phenomena. The force of crystallization, the force of gravitation, and chemical affinity remain in themselves just as incomprehensible as do Adaptation and Inheritance.

Seeing that Darwin's theory explains from a single point of view the totality of all those phenomena of which we have given a brief survey, that it demonstrates one and the same quality of the organism as the active cause in all cases, we must allow that it gives us for the present *all* that we can desire. Moreover, we have good reason to hope that at some future time we shall learn to explain the first causes at which Darwin has arrived, namely, the properties of Adaptation and Inheritance; and that we shall succeed in discovering in the composition of albuminous matter certain molecular relations as the remoter, simpler causes of these phenomena. There is indeed no prospect of this in the immediate future, and we content ourselves for the present with the tracing back of organic phenomena to two mysterious properties, just as in the case of Newton's theory we are satisfied with tracing the planetary motions to the force of gravitation, which itself is likewise a mystery to us and not cognizable in itself.

Before commencing our principal task, which is the careful discussion of the Doctrine of Descent, and the consequences that arise out of it, let us take an historical retrospect of the most important and most widely spread of those views, which before Darwin men had elaborated concerning

organic creation, and the coming into existence of the many animal and vegetable species. In doing this I have no intention of entertaining the reader with a statement of all the innumerable stories about the creation which have been current among the different human species, races, or tribes. However interesting and gratifying this task would be, from an ethnographical point of view, as well as in a history of civilization, it would lead us here much too far from our subject. Besides, the great majority of all these legends about creation bear too clearly the stamp of arbitrary fiction, and of a want of a close observance of nature, to be of interest in a scientific treatment of the history of creation. I shall therefore only select the Mosaic history from among those that are not founded on scientific investigation, on account of the unparalleled influence which it has gained in the western civilized world; and then I shall immediately take up the scientific hypothesis about creation, which originated with Linnæus as late as the commencement of last century.

All the different conceptions which man has ever formed about the coming into existence of the different animal and vegetable species may conveniently be divided into two great contrasted groups—the natural and supernatural histories of creation.

These two groups, on the whole, correspond with the two different principal forms of the human notions of the universe which we have already contrasted as the *monistic and the dualistic* conception of nature. In the usual dualistic or teleological (vital) conception of the universe, organic nature is regarded as the purposely executed production of a Creator working according to a definite plan. Its adherents see in

every individual species of animal and plant an "embodied creative thought," the material expression of a *definite first cause* (*causa finalis*) acting for a set purpose. They must necessarily assume supernatural (not mechanical) processes for the origin of organisms. With justice, we may therefore designate their scheme of the world's growth as the *Supernatural History of Creation*. Among all such teleological histories of creation, that of Moses has gained the greatest influence, since even so distinguished a naturalist as Linnaeus has claimed admittance for it in Natural Science. Cuvier's and Agassiz's views of creation also belong to this group, as do in fact those of the great majority of both scientific and unscientific men.

On the other hand, the theory of development carried out by Darwin, which we shall have to treat of here as the *Non-miraculous* or *Natural History of Creation*, and which has already been put forward by Goethe and Lamarck, must, if carried out logically, lead to the monistic or mechanical (causal) conception of the universe. In opposition to the dualistic or teleological conception of nature, our theory considers organic, as well as inorganic, bodies to be the necessary products of natural forces. It does not see in every individual species of animal and plant the embodied thought of a personal Creator, but the expression for the time being of a mechanical process of development of matter, the expression of a necessarily active cause, that is, of a mechanical cause (*causa efficiens*). Where teleological Dualism seeks the arbitrary thoughts of a capricious Creator in the miracles of creation, causal Monism finds in the process of development the necessary effects of eternal immutable laws of nature.

The Monism here maintained by us is often considered identical with Materialism. Now, as Darwinism, and in fact the whole theory of development, has been designated as "*materialistic*," I cannot avoid here at once guarding myself against this ambiguous word, and against the malice with which, in certain quarters, it is employed to stigmatize our doctrine.

By the word "*Materialism*," two completely different things are very frequently confounded and mixed up, which in reality have nothing whatever to do with each other, namely, scientific and moral materialism. Scientific materialism, which is identical with our Monism, affirms in reality no more than that everything in the world goes on naturally—that every effect has its cause, and every cause its effect. It therefore assigns to causal law—that is, the law of a necessary connection between cause and effect—its place over the entire series of phenomena that can be known. At the same time, scientific materialism positively rejects every belief in the miraculous, and every conception, in whatever form it appears, of supernatural processes. Accordingly, nowhere in the whole domain of human knowledge does it recognize real metaphysics, but throughout only physics; through it the inseparable connection between matter, form, and force becomes self evident. This scientific materialism has long since been so universally acknowledged in the wide domain of inorganic science, in Physics and Chemistry, in Mineralogy and Geology, that no one now doubts its sole authority. But in Biology, or Organic science, the case is very different; here its value is still continually a matter of dispute in many quarters. There is, however, nothing else which can be set up against it, excepting the

metaphysical spectre of a vital power, or empty theological dogma. If we can prove that all nature, so far as it can be known, is only *one*, that the same "great, eternal, iron laws" are active in the life of animals and plants, as in the growth of crystals and in the force of steam, we may with reason maintain the monistic or mechanical view of things throughout the domain of Biology—in Zoology and Botany—whether it be stigmatized as "materialism" or not. In such a sense all exact science, and the law of cause and effect at its head, is purely materialistic.

Moral, or *ethical Materialism*, is something quite distinct from scientific materialism, and has nothing whatever in common with the latter. This real materialism proposes no other aim to man in the course of his life than the most refined possible gratification of his senses. It is based on the delusion that purely material enjoyment can alone give satisfaction to man; but as he can find that satisfaction in no one form of sensuous pleasure, he dashes on wearily from one to another. The profound truth that the real value of life does not lie in material enjoyment, but in moral action—that true happiness does not depend upon external possessions, but only in a virtuous course of life—this is unknown to ethical materialism. We therefore look in vain for such materialism among naturalists and philosophers, whose highest happiness is the intellectual enjoyment of Nature, and whose highest aim is the knowledge of her laws. We find it in the palaces of ecclesiastical princes, and in those hypocrites who, under the outward mask of a pious worship of God, solely aim at hierarchical tyranny over, and material spoliation of, their fellow-men. Blind to the infinite grandeur of the so-called

“raw material,” and the glorious world of phenomena arising from it—insensible to the inexhaustible charms of Nature, and without a knowledge of her laws—they stigmatize all natural science, and the culture arising from it, as sinful “materialism,” while really it is this which they themselves exhibit in a most shocking form. Satisfactory proofs of this are furnished, not only by the whole history of the Catholic Popes, with their long series of crimes, but also by the history of the morals of orthodoxy in every form of religion.

In order, then, to avoid in future the usual confusion of this utterly objectionable Moral Materialism with our Scientific Materialism, we think it necessary to call the latter either *Monism* or *Realism*. The principle of this *Monism* is the same as what Kant terms the “principle of mechanism,” and of which he expressly asserts, that *without it there can be no natural science at all*. This principle is quite inseparable from our Non-miraculous History of Creation, and characterizes it as opposed to the teleological belief in the miracles of a Supernatural History of Creation.

Let us now first of all glance at the most important of all the supernatural histories of creation, I mean that of Moses, as it has been handed down to us in the Bible, the ancient document of the history and laws of the Jewish people. The Mosaic history of creation, since in the first chapter of Genesis it forms the introduction to the Old Testament, has enjoyed, down to the present day, general recognition in the whole Jewish and Christian world of civilization. Its extraordinary success is explained not only by its close connection with Jewish and Christian doctrines, but also by the simple and natural chain of ideas

which runs through it, and which contrasts favourably with the confused mythology of creation current among most of the other ancient nations. First the Lord God creates the earth as an inorganic body; then he separates light from darkness, then water from the dry land. Now the earth has become inhabitable for organisms, and plants are first created, animals later—and among the latter the inhabitants of the water and the air first, afterwards the inhabitants of the dry land. Finally God creates man, the last of all organisms, in his own image, and as the ruler of the earth.

Two great and fundamental ideas, common also to the non-miraculous theory of development, meet us in this Mosaic hypothesis of creation, with surprising clearness and simplicity—the idea of separation or *differentiation*, and the idea of progressive development or *perfecting*. Although Moses looks upon the results of the great laws of organic development (which we shall later point out as the necessary conclusions of the Doctrine of Descent) as the direct actions of a constructing Creator, yet in his theory there lies hidden the ruling idea of a progressive development and a differentiation of the originally simple matter. We can therefore bestow our just and sincere admiration on the Jewish lawgiver's grand insight into nature, and his simple and natural hypothesis of creation, without discovering in it a so-called "divine revelation." That it cannot be such is clear from the fact that two great fundamental errors are asserted in it, namely, first, the *geocentric* error that the earth is the fixed central point of the whole universe, round which the sun, moon, and stars move; and secondly, the *anthropocentric* error, that man is the premeditated aim of the creation of

the earth, for whose service alone all the rest of nature is said to have been created. The former of these errors was demolished by Copernicus' System of the Universe in the beginning of the 16th century, the latter by Lamarck's Doctrine of Descent in the beginning of the 19th century.

Although the geocentric error of the Mosaic history was demonstrated by Copernicus, and thereby its authority as an absolutely perfect divine revelation was destroyed, yet it has maintained, down to the present day, such influence, that it forms in many wide circles the principle obstacle to the adoption of a natural theory of development. Even in our century, many naturalists, especially geologists, have tried to bring the Mosaic theory into harmony with the recent results of natural science, and have, for example, interpreted Moses' seven days of creation as seven great geological periods. However, all these ingenious attempts at interpretation have so utterly failed, that they require no refutation here. The Bible is no scientific book, but consists of records of the history, the laws, and the religion of the Jewish people, the high merit of which, as a history of civilization, is not impaired by the fact that in all scientific questions it has no commanding importance, and is full of gross errors.

We may now make a great stride over more than three thousand years, from Moses, who died about the year 1480 before Christ, to Linnæus, who was born in the year 1707 after Christ. During this whole period no history of creation was brought forward that gained any lasting importance, or the closer examination of which would here be of any interest. Indeed, during the last fifteen hundred years, since Christianity gained its supremacy, the Mosaic history

of creation, together with the dogmas connected with it, has become so generally predominant, that the 19th century is the first that has dared positively to rise against it. Even the great Swedish naturalist, Linnæus, the founder of modern natural history, linked his System of Nature most closely to the Mosaic history of creation.

The extraordinary progress which Charles Linnæus made in the so-called descriptive natural sciences, consists, as is well known, in his having established a system of nomenclature of animals and plants, which he carried out in a manner so perfectly logical and consistent, that down to the present day it has remained in many respects the standard for all succeeding naturalists engaged in the study of the forms of animals and plants. Although Linnæus' system was artificial, although in classifying animal and vegetable species he only sought and employed single parts as the foundation for his divisions, it has, nevertheless, gained the greatest success; firstly, in consequence of its being carried out consistently, and secondly, by its nomenclature of natural bodies, which has become extremely important, and at which we must here briefly glance.

Before Linnæus' time, many vain attempts had been made to throw light upon the endless chaos of different animal and vegetable forms (then known) by adopting for them suitable names and groupings; but Linnæus, by a happy hit, succeeded in accomplishing this important and difficult task, when he established the so-called "*binary nomenclature*." The binary nomenclature, or the twofold designation, as Linnæus first established it, is still universally applied by all zoologists and botanists, and will, no doubt, maintain itself, for a long time to come, with undiminished authority.

It consists in this, that every species of animal and plant is designated by two names, which stand to each other in the same relation as do the christian and surnames of a man. The special name which corresponds with the christian name, and expresses the idea of "a species," serves as the common designation of all individual animals or plants, which are equal in all essential matters of form, and are only distinguished by quite subordinate features. The more general name, on the other hand, corresponding with the surname, and which expresses the idea of a genus, serves for the common designation of all the most nearly similar kinds or species.

According to Linnæus' plan, the more general and comprehensive generic name is written first; the special subordinate name of the species follows it. Thus, for example, the common cat is called *Felis domestica*; the wild cat, *Felis catus*; the panther, *Felis pardus*; the jaguar, *Felis onca*; the tiger, *Felis tigris*; the lion, *Felis leo*. All these six kinds of animals of prey are different species of one and the same genus—*Felis*. Or, to add an example from the vegetable kingdom, according to Linnæus' designation the pine is *Pinus abies*; the fir, *Pinus picea*; the larch, *Pinus larix*; the Italian pine, *Pinus pinea*; the Siberian stone pine, *Pinus cembra*; the knee timber, *Pinus mughus*; the common pine, *Pinus silvestris*. All these seven kinds of pines are different species of one and the same genus—*Pinus*.

Perhaps this advance made by Linnæus may seem to some only of subordinate importance in the practical distinction and designation of the variously formed organisms. But in reality it was of the very greatest importance, both from a practical and theoretical point of view. For now, for the

first time, it became possible to arrange the immense mass of different organic forms according to their greater or less degree of resemblance, and to obtain an easy survey of the general outlines of such a "system." Linnæus facilitated the tabulation and survey of this "system" of plants and animals still more by placing together the most nearly similar genera into so-called orders (ordines); and by uniting the most nearly similar orders into still more comprehensive main divisions or classes. Thus, according to Linnæus, each of the two organic kingdoms were broken up into a number of classes, the vegetable kingdom into twenty-four, and the animal kingdom into six. Each class again contains several orders. Every single order may contain a number of genera, and, again, every single genus several species.

Valuable as was Linnæus' binary nomenclature in a *practical* way, in bringing about a comprehensive systematic distinction, designation, arrangement, and division of the organic world of forms, yet the incalculable *theoretical* influence which it gained forthwith in relation to the history of creation was no less important. Even now all the important fundamental questions as to the history of creation turn finally upon the decision of the very remote and unimportant question, *What really are kinds or species?* Even now the *idea of organic species* may be termed the central point of the whole question of creation, the disputed centre, about the different conceptions of which Darwinists and Anti-Darwinists fight.

According to Darwin's opinion, and that of his adherents, the different species of one and the same genus of animals and plants are nothing else than differently developed

descendants of one and the same original primary form. The different kinds of pine mentioned above would accordingly have originated from a single primæval form of pine. In like manner the origin of all the species of cat mentioned above would be traced to a single common form of *Felis*, the ancestor of the whole genus. But further, in accordance with the Doctrine of Descent, all the different genera of one and the same order ought also to be descended from one common primary ancestor, and so, in like manner, all orders of a class from a single primary form.

On the other hand, according to the idea of Darwin's opponents, all species of animals and plants are quite independent of each other, and only the individuals of each species have originated from a single primary form. But if we ask them how they conceive these original primary forms of each species to have come into existence, they answer with a leap into the incomprehensible, "They were created."

Linnæus himself defined the idea of species in this manner by saying, "There are as many different species as there were different forms created in the beginning by the infinite Being." ("Species tot sunt diversæ, quot diversas formas ab initio creavit infinitum ens.") In this respect, therefore, he follows most closely the Mosaic history of creation, which in the same way maintains that animals and plants were created "each one after its kind." Linnæus, accepting this, held that originally of each species of animals and plants either a single individual or a pair had been created; in fact a pair, or, as Moses says, "a male and a female" of those species which have separate sexes, but of those species in which each individual combines both sexual organs (hermaphrodites), as for instance the earth-

worm, the garden and vineyard snails, as well as the great majority of plants, a single individual.

Linnæus further follows the Mosaic legend in regard to the flood, by supposing that the great general flood destroyed all existing organisms, except those few individuals of each species (seven pairs of the birds and of clean animals, one pair of unclean animals) which Noah saved in the ark, and which were placed again on land, on Mount Ararat, after the flood had subsided. He tried to explain the geographical difficulty of the living together of the most different animals and plants, as follows: Mount Ararat, in Armenia, being situated in a warm climate, and rising over 16,000 feet in height, combines in itself the conditions for a temporary common abode of such animals as live in different zones. Accordingly, animals accustomed to the polar regions could climb up the cold mountain ridges, those accustomed to a warm climate could go down to the foot of the mountain, and the inhabitants of a temperate zone could remain midway up the mountain. From this point it was possible for them to spread north and south over the earth.

It is scarcely necessary to remark that this Linnæan hypothesis of creation, which evidently was intended to harmonize most closely with the prevailing belief in the Bible, requires no serious refutation. When we consider Linnæus' clearness and sagacity in other matters, we may doubt whether he believed it himself. As to the simultaneous origin of all individuals of each species from one pair of ancestors respectively (or in the case of the hermaphrodite species, from one original hermaphrodite), it is clearly quite untenable; for, apart from other reasons, in the first days after the creation, the few animals of prey would have

sufficed to have utterly demolished all the herbivorous animals, as the herbivorous animals must have destroyed the few individuals of the different species of plants. The existence of such an equilibrium in the economy of nature as obtains at present cannot possibly be conceived, if only one individual of each species, or only one pair, had originally and simultaneously been created.

Moreover, how little importance Linnæus himself attached to this untenable hypothesis of creation is clear, among other things, from the fact that he recognized *Hybridism* (crossing) as a source of the production of new species. He assumed that a great number of independent new species had originated by the interbreeding of two different species. Indeed, such hybrids are not at all rare in nature, and it is now proved that a great number of species, for example, of the genus *Rubus* (bramble), mullein (*Verbascum*), willow (*Salix*), thistle (*Cirsium*), are hybrids of different species of these genera. We also know of hybrids between hares and rabbits (two species of the genus *Lepus*), further of hybrids between different species of dog (genus *Canis*), etc., which can be propagated as independent species.

It is certainly very remarkable that Linnæus asserted the physiological (therefore mechanical) origin of new species in this process of hybridism. It clearly stands in direct opposition to the supernatural origin of the other species by creation, which he accepted as put forward in the Mosaic account. The one set of species would therefore have originated by dualistic (teleological) creation, the other by monistic (mechanical) development.

The great and well merited authority which Linnæus gained by his systematic classification and by his other

services to Biology, was clearly the reason why his views of creation also remained, throughout the whole of the last century, undisputed and generally recognized. If throughout systematic Zoology and Botany the distinctions, classification, and designations of species, introduced by Linnæus, and the dogmatic ideas connected therewith had not been maintained—more or less unaltered—we should be at a loss to understand how his idea of an independent creation of single species could have stood, by itself, down to the present day. It is only owing to his great authority, and through his attaching himself to the prevailing Biblical belief, that his hypothesis of creation has retained its position so long.

CHAPTER III.

THE HISTORY OF CREATION ACCORDING TO CUVIER
AND AGASSIZ.

General Theoretical Meaning of the Idea of Species.—Distinction between the Theoretical and Practical Definition of the Idea of Species.—Cuvier's Definition of Species.—Merits of Cuvier as the Founder of Comparative Anatomy.—Distinction of the Four Principal Forms (types or branches) of the Animal Kingdom, by Cuvier and Bär.—Cuvier's Services to Palæontology.—His Hypothesis of the Revolutions of our Globe, and the Epochs of Creation separated by them.—Unknown Supernatural Causes of the Revolutions, and the subsequent New Creations.—Agassiz's Teleological System of Nature.—His Conception of the Plan of Creation, and its six Categories (groups in classification).—Agassiz's Views of the Creation of Species.—Rude Conception of the Creator as a man-like being in Agassiz's Hypothesis of Creation.—Its internal Inconsistency and Contradictions with the important Palæontological Laws discovered by Agassiz.

THE real matter of dissension in the contest carried on by naturalists as to the origin of organisms, their creation and development, lies in the conceptions which are entertained about the *nature of species*. Naturalists either agree with Linnæus, and look upon the different species as distinct forms of creation, independent of one another, or they assume with Darwin their blood-relationship. If we share Linnæus' view (which was discussed in our last chapter), that the different organic species came into existence independently—that they have no blood-relation-

ship—we are forced to admit that they were created independently, and we must either suppose that every single organic individual was a special act of creation (to which surely no naturalist will agree), or we must derive all individuals of every species from a single individual, or from a single pair, which did not arise in a natural manner, but was called into being by command of a Creator. In so doing, however, we turn aside from the safe domain of a rational knowledge of nature, and take refuge in the mythological belief in miracles.

If, on the other hand, with Darwin, we refer the similarity of form of the different species to real blood-relationship, we must consider all the different species of animals and plants as the altered descendants of one or a few most simple original forms. Viewed in this way, the Natural System of organisms (that is, their tree-like and branching arrangement and division into classes, orders, families, genera, and species) acquires the significance of a real genealogical tree, whose root is formed by those original archaic forms which have long since disappeared. But a truly natural and consistent view of organisms can assume no supernatural act of creation for even those simplest original forms, but only a coming into existence by *spontaneous generation** (archigony, or generatio spontanea). From Darwin's view of the nature of species, we arrive therefore at a *natural theory of development*; but from Linnæus' conception of the idea of species, we must assume a *supernatural dogma of creation*.

Most naturalists after Linnæus, whose great services in

* Archebiosis (Bastian), Abiogenesis (Huxley).

systematic and descriptive natural history won for him such high authority, followed in his footsteps, and without further inquiry into the origin of organization, they assumed, in the sense of Linnæus, an independent creation of individual species, in conformity with the Mosaic account of creation. The foundation of their conception was based upon Linnæus' words: "There are as many different species as there were different forms created in the beginning by the Infinite Being." We must here remark at once, without going further into the definition of species, that all zoologists and botanists in their classificatory systems, in the practical distinction and designation of species of animals and plants, never troubled, or even could trouble, themselves in the slightest degree about this assumed creation of the parent forms. In reference to this, one of our first zoologists, the ingenious Fritz Müller, makes the following striking observation: "Just as in Christian countries there is a catechism of morals, which every one knows by heart, but which no one considers it his duty to follow, or expects to see followed by others,—so zoology also has its dogmas, which are just as generally professed as they are denied in practice." (Für Darwin, p. 71.)¹⁶

Linnæus' venerated dogma of species is just such an irrational dogma, and for that very reason it is powerful. Although most naturalists blindly submitted to it, yet they were, of course, never in a position to demonstrate the descent of individuals belonging to one species from the common, originally created, primitive form. Zoologists and botanists, in their systems of nomenclature, confined themselves entirely to the similarity of forms, in order to distinguish and name the different species. They placed in one species

all organic individuals which were very similar, or almost identical in form, and which could only be distinguished from one another by very unimportant differences. On the other hand, they considered as different species those individuals which presented more essential or more striking differences in the formation of their bodies. But of course this opened the flood-gates to the most arbitrary proceedings in the systematic distinctions of species. For as all the individuals of one species are never completely alike in all their parts, but as every species varies more or less, no one could point out which degree of variation constituted a really "good species," or which degree indicated a "mere variety."

This dogmatic conception of the idea of species, and the arbitrary proceedings connected with it, necessarily led to the most perplexing contradictions, and to the most untenable suppositions. This is clearly demonstrable in the case of the celebrated Cuvier (born in 1769), who next to Linnæus has exercised the greatest influence on the study of zoology. In his conception and definition of the idea of species, he agreed on the whole with Linnæus, and shared also his belief in an independent creation of individual species. Cuvier considered their immutability of such importance that he was led to the foolish assertion—"The immutability of species is a necessary condition of the existence of scientific natural history." As Linnæus' definition of species did not satisfy him, he made an attempt to give a more exact and, for systematic practice, a more useful definition, in the following words: "All those individual animals and plants belong to one species which can be proved to be either descended

from one another, or from common ancestors, or which are as similar to these as the latter are among themselves."

In dealing with this matter, Cuvier reasoned in the following manner:—"In those organic individuals, of which we know that they are descended from one and the same common form of ancestors—in which, therefore, their common ancestry is empirically proved—there can be no doubt that they belong to one species, whether they differ much or little from one another, or whether they are almost alike or very unlike. Moreover, all those individuals also belong to this species which differ no more from the latter (those proved to be derived from a common stock) than these differ from one another." In a closer examination of this definition of species given by Cuvier, it becomes at once evident that it is neither theoretically satisfactory nor practically applicable. Cuvier, with this definition, began to move in the same circle in which almost all subsequent definitions of species have moved, through the assumption of their immutability.

Considering the extraordinary authority which George Cuvier has gained in the science of organic nature, and in consequence of the almost unlimited supremacy which his views exercised in zoology, during the first half of our century, it seems appropriate here to examine his influence a little more closely. This is all the more necessary as we have to combat, in Cuvier, the most formidable opponent to the Theory of Descent and the monistic conception of nature.

One of the many and great merits of Cuvier is that he stands forth as the founder of Comparative Anatomy. While Linnæus established the distinction of species, genera, orders, and classes mostly upon external characters, and upon sepa-

rate and easily discoverable signs in the number, size, place, and form of individual organic parts of the body, Cuvier penetrated much more deeply into the essence of organization. He demonstrated great and wide differences in the inner structure of animals, as the real foundation of a scientific knowledge and classification of them. He distinguished natural families in the classes of animals, and established his natural system of the animal kingdom on their comparative anatomy.

The progress from Linnæus' artificial system to Cuvier's natural system was exceedingly important. Linnæus had arranged all animals in a single series, which he divided into six classes, two classes of Invertebrate, and four classes of Vertebrate animals. He distinguished these artificially, according to the nature of their blood and heart. Cuvier, on the other hand, showed that in the animal kingdom there were four great natural divisions to be distinguished, which he termed Principal Forms, or General Plans, or Branches of the animal kingdom (Embranchments), namely—1. The Vertebrate animals (Vertebrata); 2. The Articulate animals (Articulata); 3. The Molluscous animals (Mollusca); and 4. The Radiate animals (Radiata). He further demonstrated that in each of these four branches a peculiar plan of structure or type was discernible, distinguishing each branch from the three others. In the Vertebrate animals it is distinctly expressed by the form of the skeleton, or bony framework, as also by the structure and position of the dorsal nerve-chord, apart from many other peculiarities. The Articulate animals are characterized by their ventral nerve-chord and their dorsal heart. In Molluscs the sack-shaped and non-articulate body is the distinguishing feature.

The Radiate animals, finally, differ from the three other principal forms by their body being the combination of four or more main sections united in the form of radii (antimera).

The distinction of these four principal forms of animals, which has become extremely productive in the development of zoology, is commonly ascribed entirely to Cuvier. However, the same thought was expressed almost simultaneously, and independently of Cuvier, by Bär, one of the greatest naturalists, and still living, who did the most eminent service in the study of animal development. Bär showed that in the development of animals, also, four different main forms (or types) must be distinguished.²⁰ These correspond with the four plans of structure in animals, which Cuvier distinguished on the ground of comparative anatomy. Thus, for example, the individual development of all Vertebrate animals agrees, from the commencement, so much in its fundamental features that the germs or embryos of different Vertebrate animals (for example, of reptiles, birds, and mammals) in their earlier stages cannot be distinguished at all. It is only at a late stage of development that there gradually appear the more marked differences of form which separate those different classes and orders from one another. The plan of structure, which shows itself in the individual development of Articulate animals (insects, spiders, crabs), is from the beginning essentially the same in all Articulate animals, but different from that of all Vertebrate animals. The same holds good, with certain limitations, in Molluscous and Radiated animals.

Neither Bär, who arrived at the distinction of the four animal types or principal forms through the history of the individual development (Embryology), nor Cuvier, who

arrived at the same conclusion by means of comparative anatomy, recognized the true cause of this difference. This is disclosed to us by the Theory of Descent. The wonderful and astonishing similarity in the inner organization and in the anatomical relations of structure, and the still more remarkable agreement in the embryonic development of all animals belonging to one and the same type (for example, to the branch of the Vertebrate animals), is explained in the simplest manner by the supposition of their common descent from a single primary original form. If this view is not accepted, then the complete agreement of the most different Vertebrate animals, in their inner structure and their manner of development, remains perfectly inexplicable. In fact it can only be explained by the law of *inheritance*.

Next to the comparative anatomy of animals and the systematic zoology founded anew by it, it was specially to the science of petrifications, or Palæontology, that Cuvier rendered great service. We must draw special attention to this, because these very palæontological views, and the geological ideas connected with them, were held almost universally in the highest esteem during the first half of the present century, and caused the greatest hindrance to the working out of a truly natural history of creation.

Petrifications, the scientific study of which Cuvier promoted at the beginning of our century in a most extensive manner, and established quite anew for the Vertebrate animals, play one of the most important parts in the "non-miraculous history of creation." For these remains and impressions of extinct animals and plants, preserved to us in a petrified condition, are the true "monuments of the

creation," the infallible and indisputable records which fix the correct history of organisms upon an irrefragable foundation. All petrified or fossil remains and impressions tell us of the forms and structure of such animals and plants as are either the progenitors and ancestors of the present living organisms, or they are the representatives of extinct collateral lines, which, together with the present living organisms, branched off from a common stem.

These inestimable records of the history of creation throughout a long period played a subordinate part in science. Their true nature was indeed correctly understood, even more than five hundred years before Christ, by the great Greek philosopher, Xenophanes of Colophon, the same who founded the so-called Eleatic philosophy, and who was the first to demonstrate with convincing precision that all conceptions of personal gods result in more or less rude anthropomorphism.

Xenophanes for the first time asserted that the fossil impressions of animals and plants were real remains of formerly living creatures, and that the mountains in whose rocks they were found must at an earlier date have stood under water. But although other great philosophers of antiquity, and among them Aristotle, also possessed this true knowledge, yet throughout the illiterate Middle Ages, and even with some naturalists of the last century, the idea prevailed that petrifications were so-called freaks of nature (*lusus naturæ*), or products of an unknown formative power or instinct of nature (*nisus formativus, vis plastica*). Respecting the nature of this mysterious and mystic creative power, the strangest ideas were formed. Some believed that this constructive power—the same to which they also

ascribed the coming into existence of the present species of animals and plants—had made numerous attempts to create organisms of different forms, but that these attempts had only partially succeeded, had often failed, and that petrifications were nothing more than such unsuccessful attempts. According to others, petrifications originated from the influence of the stars upon the interior of the earth.

Others, again, had the still cruder notion that the Creator had first made models (out of mineral substances—for example, of gypsum or clay) of those forms of animals and plants which he afterwards executed in organic substances, and into which he breathed his living breath; petrifications were accordingly such rude inorganic models. Even as late as the last century these crude ideas prevailed, and it was assumed, for example, that there existed a special “seminal air,” which was said to penetrate into the earth with the water, and by fructifying the stones formed petrifications or “stony flesh” (*caro fossilis*).

It took a very long time before the simple and natural view was accepted, namely, that petrifications are in reality nothing but what they appear to simple observation—the indestructible remains of extinct organisms. It is true the celebrated painter, Leonardo da Vinci, in the 15th century, ventured to assert that the mud which was constantly deposited by water was the cause of petrifications, as it surrounded the indestructible shells of mussels and snails which lay at the bottom of the waters, and gradually turned them into solid stone. The same idea was maintained in the 16th century by a Parisian potter, Palissy by name, who became celebrated on account of his invention of china. However, the so-called “professional men” were

very far from paying any regard to these correct assertions of a simple and healthy human understanding; it was not till the end of the last century that it was generally accepted, in consequence of the foundation of the Neptunian geology by Werner.

The foundation of a more strictly scientific palæontology, however, belongs to the beginning of our century, when Cuvier published his classic researches on petrified Vertebrate animals, and when his great opponent, Lamarck, made known his remarkable investigations on fossil Invertebrate animals, especially on petrified snails and clams. In Cuvier's celebrated work "On the Fossil Bones" of Vertebrate animals—principally of mammals and reptiles—we see that he had already arrived at the knowledge of some very important and general palæontological laws, which are of great consequence to the history of creation. Foremost among them stands the assertion that the extinct species of animals, whose remains we find petrified in the different strata of the earth's crust, lying one above another, differ all the more strikingly from the still living kindred species of animals the deeper those strata lie—in other words, the earlier the animals lived in past ages. In fact, in every perpendicular section of the stratified crust of the earth we find that the different strata, deposited by the water in a certain historical succession, are characterized by different petrifications, and that these extinct organisms become more like those of the present day the higher the strata lie; in other words, the more recent the period in the earth's history in which they lived, died, and became encrusted by the deposited and hardened strata of mud.

However important this general observation of Cuvier's

was in one sense, yet in another it became to him the source of a very serious error. For as he considered the characteristic petrifications of each individual group of strata (which had been deposited during one main period of the earth's history) to be entirely different from those of the strata lying above or below, and as he erroneously believed that one and the same species of animal was never found in two succeeding groups of strata, he arrived at the false idea, which was accepted as a law by most subsequent naturalists, that a series of quite distinct periods of creation had succeeded one another. Each period was supposed to have had its special animal and vegetable world, each its peculiar specific Fauna and Flora.

Cuvier imagined that the whole history of the earth's crust, since the time when living creatures had first appeared on the surface, must be divided into a number of perfectly distinct periods, or divisions of time, and that the individual periods must have been separated from one another by peculiar revolutions of an unknown nature (cataclysms, or catastrophes). Each revolution was followed by the utter annihilation of the till then existing animals and plants, and after its termination a completely new creation of organic forms took place. A new world of animals and plants, absolutely and specifically distinct from those of the preceding historical periods, was called into existence at once, and now again peopled the globe for thousands of years, till it again perished suddenly in the crash of a new revolution.

About the nature and causes of these revolutions, Cuvier expressly said that no idea could be formed, and that the present active forces in nature were not sufficient for their explanation. Cuvier points out four active causes as the

natural forces, or mechanical agents, at present constantly but slowly at work in changing the earth's surface: first, *rain*, which washes down the steep mountain slopes and heapes up *débris* at their foot; secondly, *flowing waters*, which carry away this *débris* and deposit it as mud in stagnant waters; thirdly, the *sea*, whose breakers gnaw at the steep sea coasts, and throw up "dunes" on the flat sea margins; finally and fourthly, *volcanos*, which break through and heave up the strata of the earth's hardened crust, and pile up and scatter about the products of their eruptions. Whilst Cuvier recognizes the constant slow transformation of the present surface of the earth by these four mighty causes, he asserts at the same time that they would not have sufficed to effect the revolutions of the remote ages, and that the anatomical structure of the earth's surface cannot be explained by the necessary action of those mechanical agents: the great and marvellous revolutions of the whole earth's surface must, according to him, have been rather the effects of very peculiar causes, completely unknown to us; the usual thread of development was broken by them, and the course of nature altered.

These views Cuvier explained in a special work "On the Revolutions of the Earth's Surface, and the Changes which they have wrought in the Animal World." They were maintained, and generally accepted for a long time, and became the greatest obstacle to the development of a natural history of the creation. For if such all-destructive revolutions had actually occurred, of course a continuity of the development of species, a connecting thread in the organic history of the earth, could not be admitted at all, and we

should be obliged to have recourse to the action of supernatural forces; that is, to the interference of miracles in the natural course of things. It is only through miracles that these revolutions of the earth could have been brought about, and it is only through miracles that, after their cessation and at the commencement of each new period, a new animal and vegetable kingdom could have been created. But science has no room for miracles, for by miracles we understand an interference of supernatural forces in the natural course of development of matter.

Just as the great authority which Linnæus gained by his system of distinguishing and naming organic species led his successors to a complete ossification, as it were, of the dogmatic idea of species and to a real abuse of the systematic distinction implied by it, so the great services which Cuvier had rendered to the knowledge and distinction of extinct species became the cause of a general adoption of his theory of revolutions and catastrophes, and of the false views of creation connected therewith. The consequence of this was that, during the first half of our century, most zoologists and botanists clung to the opinion that a series of independent periods in the organic history of the earth had existed; that each period was distinguished by distinct and peculiar kinds of animal and vegetable species; that these were annihilated at the termination of the period by a general revolution; and that, after the cessation of the latter, a new world of different species of animals and plants was created.

It is true some independent thinkers, above all the great physical philosopher, Lamarck, even at an early period, set forth a series of weighty reasons which refuted Cuvier's

theory of cataclysms, and pointed to a perfectly continuous and uninterrupted developmental history of all the organic inhabitants of the earth through all ages. They maintained that the animal and vegetable species of each period were derived from those of the preceding period, and were only the altered descendants of the former. This true conception, however, being opposed to Cuvier's great authority, was then unable to make way. Nay, even after Cuvier's theory of catastrophies had been completely cast out from the domain of geology by Lyell's classic *Principles of Geology*, which appeared in 1830, still his idea of the specific distinctness of a series of organic creations maintained its influence, in many ways, in the science of Palæontology. (*Gen. Morph.* ii. 312.)

By a curious coincidence, thirteen years ago, almost at the same time that Cuvier's *History of Creation* received its death-blow by Darwin's book, another celebrated naturalist made an attempt to re-establish it, and to adopt it in the roughest manner, as a part of a teleologico-theological system of nature. This was the Swiss geologist, Louis Agassiz, who attained a great reputation by his theory of glaciers and the ice-period, borrowed from Schimper and Charpentier, and who has been living in North America for many years. He commenced in 1858 to publish a work planned on a very large scale, which bears the title of "*Contributions to the Natural History of the United States of North America.*" The first volume of this work, although large and costly, owing to the patriotism of the Americans, had an unprecedented sale; its title is, "*An Essay on Classification.*"⁵

In this essay Agassiz not only discusses the natural series

of organisms, and the different attempts of naturalists at classification, but also all the general biological phenomena which have reference to it. The history of the development of organisms, both the embryonal and the palæontological, comparative anatomy, the general economy of nature, the geographical and topographical distribution of animals and plants—in short, almost all the general phenomena of organic nature are discussed in Agassiz's Essay on Classification, and are explained in a sense and from a point of view which is thoroughly opposed to that of Darwin. While Darwin's chief merit lies in the fact that he demonstrates natural causes for the coming into existence of animal and vegetable species, and thereby establishes the mechanical or monistic view of the universe as regards this most difficult branch of the history of creation, Agassiz, on the contrary, strives to exclude every mechanical hypothesis from the subject, and to put the supernatural interference of a personal Creator in the place of the natural forces of matter; consequently, to establish a thoroughly teleological or dualistic view of the universe. It will not be out of place if I examine a little more closely Agassiz's biological views, and especially his ideas of creation, because no other work of our opponents treats the important fundamental questions with equal minuteness, and because the utter untenableness of the dualistic conception of nature becomes very evident from the failure of this attempt.

The organic *species*, the various conceptions of which we have above designated as the real centre of dispute in the opposed views of creation, is looked upon by Agassiz, as by Cuvier and Linnæus, as a form unchangeable in all its essential characteristics. The species may indeed change

and vary within certain narrow limits ; never in essential qualities, but only in unessential points. No new species could ever proceed from the changes or varieties of a species. Not one of all organic species, therefore, is ever derived from another, but each individual species has been separately created by God. Each individual species, as Agassiz expresses it, is "an embodied creative thought" of God.

In direct opposition to the fact established by palæontological experience, that the duration of the individual organic species is most unequal, and that many species continue unchanged through several successive periods of the earth's history, while others only existed during a small portion of such a period, Agassiz maintains that one and the same species never occurs in two different periods, but that each individual period is characterized by species of animals and plants which are quite peculiar, and belong to it exclusively. He further shares Cuvier's opinion that the whole of these inhabitants were annihilated by the great and universal revolutions of the earth's surface, which divide two successive periods, and that after its destruction a new and specifically different assemblage of organisms was created. This new creation Agassiz supposes to have taken place in this manner : viz., that at each creation all the inhabitants of the earth, in their full average number of individuals, and in the peculiar relations corresponding to the economy of nature, were, as a whole, suddenly placed upon the earth by the Creator. In saying this he puts himself in opposition to one of the most firmly established and most important laws of animal and vegetable geography—namely, to the law that each species has a single original locality of origin, or a so-called "centre of creation," from

which it has gradually spread over the rest of the earth. Instead of this, Agassiz assumes each species to have been created at several points of the earth's surface, and that in each case a large number of individuals was created.

The "natural system" of organisms, the different groups and categories of which arranged above one another—namely, the branches, classes, orders, families, genera, and species—we consider, in accordance with the Theory of Descent, as different branches and twigs of the organic family-tree, is, according to Agassiz, the direct expression of the divine plan of creation, and the naturalist, while investigating the natural system, repeats the creative thoughts of God. In this Agassiz finds the strongest proof that man is the image and child of God. The different stages of groups or categories of the natural system correspond with the different stages of development which the divine plan of creation had attained. The Creator, in projecting and carrying out this plan, starting from the most general ideas of creation, plunged more and more into specialities. For instance, when creating the animal kingdom, God had in the first place four totally distinct ideas of animal bodies, which he embodied in the different structures of the four great, principal forms, types, or branches of the animal kingdom; namely, vertebrate animals, articulate animals, molluscous animals, and radiate animals. The Creator then, having reflected in what manner he might vary these four different plans of structure, next created within each of the four principal forms, several different classes—for example, in the vertebrate animal form, the classes of mammals, birds, reptiles, amphibious animals, and fishes. Then God further reflected upon the individual classes, and by

various modifications in the structure of each class, he produced the individual orders. By further variation in the order, he created natural families. As the Creator further varied the peculiarities of structure of individual parts in each family, genera arose. In further meditation on his plan of creation, he entered so much into detail that individual species came into existence, which, consequently, are embodied creative thoughts of the most special kind. It is only to be regretted that the Creator expressed these most special and most deeply considered "creative thoughts" in so very indistinct and loose a manner, and that he imprinted so vague a stamp upon them, and permitted them to vary so freely that not one naturalist is able to distinguish the "good" from the "bad species," or a genuine species from varieties, races, etc. (Gen. Morph. ii. 373.)

We see, then, according to Agassiz's conception, that the Creator, in producing organic forms, goes to work exactly as a human architect, who has taken upon himself the task of devising and producing as many different buildings as possible, for the most manifold purposes, in the most different styles, in various degrees of simplicity, splendour, greatness, and perfection. This architect would perhaps at first choose four different styles for all these buildings, say the Gothic, Byzantine, Chinese, and Rococo styles. In each of these styles he would build a number of churches, palaces, garrisons, prisons, and dwelling-houses. Each of these different buildings he would execute in ruder and more perfect, in greater and smaller, in simpler and grander fashion, etc. However, the human architect would perhaps, in this respect, be better off than the divine Creator, as he would have perfect liberty in the number of graduated subordinate

groups. The Creator, however, according to Agassiz, can only move within six groups or categories: the species, genus, family, order, class, and type. More than these six categories do not exist for him.

When we read Agassiz's book on classification, and see how he carries out and establishes these strange ideas, we can scarcely understand how, with all the appearance of scientific earnestness, he can persevere in his idea of the divine Creator as a man-like being (anthropomorphism), for by his explanation of details he produces a picture of the most absurd nonsense. In the whole series of these suppositions the Creator is nothing but an all-mighty man, who, plagued with *ennui*, amuses himself with planning and constructing most varied toys in the shape of organic species. After having diverted himself with these for thousands of years, they become tiresome to him, he destroys them by a general revolution of the earth's surface, and thus throws the whole of the useless toys in heaps together; then, in order to while away his time with something new and better, he calls a new and more perfect animal and vegetable world into existence. But in order not to have the trouble of beginning the work of creation over again, he keeps, in the main, to his original plan of creation, and creates merely new species, or at most only new genera, and much more rarely new families, new orders, or classes. He never succeeds in producing a new style or type, and always keeps strictly within the six categories or graduated groups.

When, according to Agassiz, the Creator has thus amused himself for thousands of millions of years with constructing and destroying a series of different creations, at last (but very late) he is struck with the happy thought of creating

something like himself, and so makes man in his own image. The end of all the history of creation is thus arrived at and the series of revolutions of the earth is closed. Man, the child and image of God, gives him so much to do, causes him so much pleasure and trouble, that he is wearied no longer, and therefore need not undertake a new creation. It is clear that if, according to Agassiz, we once assign to the Creator entirely human attributes and qualities, and regard his work of creation as entirely analogous to human creative activity, we are necessarily obliged to admit such utterly absurd inferences as those just stated.

The many intrinsic contradictions and perversities in Agassiz's view of creation—a view which necessarily led him to the most decided opposition to the Theory of Descent—must excite our astonishment all the more because, in his earlier scientific works, he had in many respects actually paved the way for Darwin, especially by his researches in Palæontology. Among the numerous investigations which created general interest in the then young science of Palæontology, those of Agassiz, especially his celebrated work on "Fossil Fish," rank next in importance to Cuvier's work, which formed the foundation of the science. The petrified fish, with which Agassiz has made us acquainted, have not only an extremely great importance for the understanding of all groups of Vertebrate animals, and their historical development, but we have arrived through them at a sure knowledge of important general laws of development, some of which were first discovered by Agassiz. He it was who drew special attention to the remarkable parallelism between the embryonal and the palæontological development—between ontogeny

and phylogeny, which I have already (p. 10) claimed as one of the strongest pillars of the Theory of Descent. No one before had so distinctly stated as Agassiz did, that, of the Vertebrate animals, fishes alone existed, at first, that amphibious animals came later, and that birds and mammals appeared only at a much later period; further, that among mammals, as among fishes, imperfect and lower orders had appeared first, but more perfect and higher orders at a later period. Agassiz, therefore, showed that the palæontological development of the whole Vertebrate group was not only parallel with the embryonic, but also with the systematic development, that is, with the graduated series which we see everywhere in the system, ascending from the lower to the higher classes, orders, etc.

In the earth's history lower forms appeared first, the higher forms later. This important fact, as well as the agreement of the embryonic and palæontological development, is explained quite simply and naturally by the Doctrine of Descent, and without it is perfectly inexplicable. This cause holds good also in the great law of *progressive development*, that is, of the historical progress of organization, which is traceable, broadly and as a whole, in the historical succession of all organisms, as well as in the special perfecting of individual parts of animal bodies. Thus, for example, the skeleton of Vertebrate animals acquired at first slowly, and by degrees, that high degree of perfection which it now possesses in man and the other higher Vertebrate animals. This progress, acknowledged in point of fact by Agassiz, necessarily follows from Darwin's Doctrine of Descent, which demonstrates its active causes. If this doctrine is correct, the perfecting and diver-

sification of animal and vegetable species must of necessity have gradually increased in the course of the organic history of the earth, and could only attain its highest perfection in most recent times.

The above-mentioned laws of development, together with some other general ones, which have been expressly admitted and justly emphasized by Agassiz, and some of which have first been set forth by him, are, as we shall see later, only explicable by the Theory of Descent, and without it remain perfectly incomprehensible. The conjoint action of Inheritance and Adaptation, as explained by Darwin, can alone be their true cause. But they all stand in sharp and irreconcilable opposition to the hypothesis of creation maintained by Agassiz, as well as to the idea of a personal Creator who acts for a definite purpose. If we seriously wish to explain those remarkable phenomena and their inter-connection by Agassiz's theory, then we are necessarily driven to the curious supposition that the Creator himself has developed, together with the organic nature which he created and modelled. We can, in that case, no longer rid ourselves of the idea that the Creator himself, like a human being, designed, improved, and finally, with many alterations, carried out his plans. "Man grows as higher grow his aims," and the same supposition, so unworthy of a God, must be applied to him. Although, from the reverence with which, in every page, Agassiz speaks of the Creator, it might appear that, on his theory, we attain to the sublimest conception of the divine activity in nature, yet the contrary is in truth the case. The divine Creator is degraded to the level of an idealized man, of an organism progressing in development!

Considering the wide popularity and great authority which Agassiz's work has gained, and which is perhaps justified on account of earlier scientific services rendered by the author, I have thought it my duty here to show the utter untenableness of his general conceptions. So far as this work pretends to be a scientific history of creation, it is undoubtedly a complete failure. But still it has great value, being the only detailed attempt, adorned with scientific arguments, which an eminent naturalist of our day has made to found a teleological or dualistic history of creation. The utter impossibility of such a history has thus been made obvious to every one. No opponent of Agassiz could have refuted the dualistic conception of organic nature and its origin more strikingly than he himself has done by the intrinsic contradictions which present themselves everywhere in his theory.

The opponents of the monistic or mechanical conception of the world have welcomed Agassiz's work with delight, and find in it a perfect proof of the direct creative action of a personal God. But they overlook the fact that this personal Creator is only an idealized organism, endowed with human attributes. This low dualistic conception of God corresponds with a low animal stage of development of the human organism. The more developed man of the present day is capable of, and justified in, conceiving that infinitely nobler and sublimer idea of God which alone is compatible with the monistic conception of the universe, and which recognizes God's spirit and power in all phenomena without exception. This monistic idea of God, which belongs to the future, has already been expressed by Giordano Bruno in the following words:—"A spirit exists in all

things, and no body is so small but contains a part of the divine substance within itself, by which it is animated." It is of this noble idea of God that Goethe says :—"Certainly there does not exist a more beautiful worship of God than that which needs no image, but which arises in our heart from converse with Nature." By it we arrive at the sublime idea of the Unity of God and Nature.

CHAPTER IV.

THEORY OF DEVELOPMENT ACCORDING TO GOETHE
AND OKEN.

Scientific Insufficiency of all Conceptions of a Creation of Individual Species.

—Necessity of the Counter Theories of Development.—Historical Survey of the Most Important Theories of Development.—Aristotle.—His Doctrine of Spontaneous Generation.—The Meaning of Natural Philosophy.—Goethe.—His Merits as a Naturalist.—His Metamorphosis of Plants.—His Vertebral Theory of the Skull.—His Discovery of the Mid Jawbone in Man.—Goethe's Interest in the Dispute between Cuvier and Geoffroy St. Hilaire.—Goethe's Discovery of the Two Organic Formative Principles, of the Conservative Principle of Specification (by Inheritance), and of the Progressive Principle of Transformation (by Adaptation).—Goethe's Views of the Common Descent of all Vertebrate Animals, including Man.—Theory of Development according to Gottfried Reinhold Treviranus.—His Monistic Conception of Nature.—Oken.—His Natural Philosophy.—Oken's Theory of Protoplasm.—Oken's Theory of Infusoria (Cell Theory).—Oken's Theory of Development.

ALL the different ideas which we may form of a separate and independent origin of the individual organic species by creation lead us, when logically carried out, to a so-called *anthropomorphism*, that is, to imagining the Creator as a man-like being, as was shown in our last chapter. The Creator becomes an organism who designs a plan, reflects upon and varies this plan, and finally forms creatures according to this plan, as a human architect would his building. If even such eminent naturalists as

Linnæus, Cuvier, and Agassiz, the principal representatives of the dualistic hypothesis of creation, could not arrive at a more satisfactory view, we may take it as evidence of the insufficiency of all those conceptions which would derive the various forms of organic nature from a creation of individual species.

Some naturalists, indeed, seeing the complete insufficiency of these views, have tried to replace the idea of a personal Creator by that of an unconsciously active and creative Force of Nature; yet this expression is evidently merely an evasive phrase, as long as it is not clearly shown what this force of nature is, and how it works. Hence these attempts, also, have been absolute failures. In fact, whenever an independent origin of the different forms of animals and plants has been assumed, naturalists have found themselves compelled to fall back upon so many "acts of creation," that is, on supernatural interferences of the Creator in the natural course of things, which in all other cases goes on without interference.

It is true that several teleological naturalists, feeling the scientific insufficiency of a supernatural "*creation*," have endeavoured to save the hypothesis by wishing it to be understood that creation "is nothing else than a way of coming into being, unknown and inconceivable to us." The eminent Fritz Müller has cut off from this sophistic evasion every chance of escape by the following striking remark:—"It is intended here only to express in a disguised manner the shamefaced confession, that they neither have, nor care to have, *any opinion* about the origin of species. According to this explanation of the word, we might as well speak of the creation of cholera, or syphilis, of the creation of a

conflagration, or of a railway accident, as of the creation of man." (Jenaische Zestschrift, bd. v. p. 272.)

In the face, then, of these hypotheses of creation, which are scientifically insufficient, we are forced to seek refuge in the *counter-theory of development* of organisms, if we wish to come to a rational conception of the origin of organisms. We are forced and obliged to do so, even if the theory of development only throws a glimmer of probability upon a mechanical, natural origin of the animal and vegetable species; but all the more if, as we shall see, this theory explains all facts simply and clearly, as well as completely and comprehensively. The theories of development are by no means, as they often falsely are represented to be, arbitrary fancies, or wilful products of the imagination, which only attempt approximately to explain the origin of this or that individual organism; but they are theories founded strictly on science, which explain in the simplest manner, from a fixed and clear point of view, the whole of organic natural phenomena, and more especially the origin of organic species, and demonstrate them to be the necessary consequences of mechanical processes in nature.

As I have already shown in the second chapter, all these theories of development coincide naturally with that general theory of the universe which is usually designated as the uniform or *monistic*, often also as the *mechanical* or *causal*, because it only assumes mechanical causes, or *causes working by necessity* (*causæ efficientes*), for the explanation of natural phenomena. In like manner, on the other hand, the supernatural hypotheses of creation which we have already discussed coincide completely with the opposite view of the universe, which in contrast to the former is called the

twofold or *dualistic*, often the *teleological* or vital, because it traces the organic natural phenomena to final causes, acting and *working for a definite purpose* (*causæ finales*). It is this deep and intrinsic connection of the different theories of creation with the most important questions of philosophy that incites us to their closer examination.

The fundamental idea, which must necessarily lie at the bottom of all natural theories of development, is that of a *gradual development of all (even the most perfect) organisms* out of a single, or out of a very few, quite simple, and quite imperfect original beings, which came into existence, not by supernatural creation, but by *spontaneous generation*, or archigony, out of inorganic matter. In reality, there are two distinct conceptions united in this fundamental idea, but which have, nevertheless, a deep intrinsic connection—namely, first, the idea of spontaneous generation (or archigony) of the original primary beings; and secondly, the idea of the progressive development of the various species of organisms from those most simple primary beings. These two important mechanical conceptions are the inseparable fundamental ideas of every theory of development, if scientifically carried out. As it maintains the derivation of the different species of animals and plants from the simplest, common primary species, we may term it also the Doctrine of Filiation, or *Theory of Descent*; as there is also a change of species connected with it, it may also be termed the *Transmutation Theory*.

While the supernatural histories of creation must have originated thousands of years ago, in that very remote primitive age when man, first developing out of the monkey-state, began for the first time to think more closely about

himself, and about the origin of the world around him, the natural theories of development, on the other hand, are necessarily of much more recent origin. These views are met with only among nations of a more matured civilization, to whom, by philosophic culture, the necessity of a knowledge of natural causes has become apparent; and even among these, only individual and specially gifted natures can be expected to have recognized the origin of the world of phenomena, as well as its course of development, as the necessary consequences of mechanical, naturally active causes. In no nation have these preliminary conditions, for the origin of a natural theory of development, ever existed in so high a degree as among the Greeks of classic antiquity. But, on the other hand, they lacked a close acquaintance with the facts of the processes and forms of nature, and, consequently, the foundation based upon experience, for a satisfactory unravelling of the problem of development. Exact investigation of nature, and the knowledge of nature founded on an experimental basis, was of course almost unknown to antiquity, as well as to the Middle Ages, and is only an acquisition of modern times. We have therefore here no special occasion to examine the natural theories of development of the various Greek philosophers, since they were wanting in the knowledge gained by experience, both of organic and inorganic nature, and since they almost always, as the consequence, lost themselves in airy speculations.

One man only must be mentioned here by way of exception,—Aristotle, the greatest and the only truly great naturalist of antiquity and the Middle Ages, one of the grandest geniuses of all time. To what a degree he stands

there alone, during a period of more than two thousand years, in the region of empirico-philosophical knowledge of nature, and especially in his knowledge of organic nature, is proved to us by the precious remains of his but partially surviving works. In them many traces are found of a theory of natural development. Aristotle assumes, as a matter of certainty, that spontaneous generation was the natural manner in which the lower organic creatures came into existence. He describes animals and plants originating from matter itself, through its own original force; as, for example, moths from wool, fleas from putrid dung, wood-lice from damp wood, etc. But as the distinction of organic species, which Linnæus only arrived at two thousand years later, was unknown to him, he could form no ideas about their genealogical relations.

The fundamental notion of the theory of development, that the different species of animals and plants have been developed from a common primary species by transformation, could of course only be clearly asserted after the kinds or species themselves had become better known, and after the extinct species had been carefully examined and compared with the living ones. This was not done until the end of the last and the beginning of the present century. It was not until the year 1801 that the great Lamarck expressed the theory of development, which he, in 1809, further elaborated in his classical "*Philosophie Zoologique*." While Lamarck and his countryman, Geoffroy St. Hilaire, in France, opposed Cuvier's views, and maintained a natural development of organic species by transformation and descent, Goethe and Oken at the same time pursued the same course in Germany, and helped to establish the theory

of development. As these naturalists are generally called nature-philosophers (Naturphilosophen), and as this ambiguous designation is correct in a certain sense, it appears to me appropriate here to say a few words about the correct estimate of the "Naturphilosophie."

Although for many years in England the ideas of natural science and philosophy have been looked upon as almost equivalent, and as every truly scientific investigator of nature is most justly called there a "natural philosopher," yet in Germany for more than half a century natural science has been kept strictly distinct from philosophy, and the union of the two into a true philosophy of nature is recognized only by the few. This misapprehension is owing to the fantastic eccentricities of earlier German natural-philosophers, such as Oken, Schelling, etc.; they believed that they were able to construct the laws of nature in their own heads, without being obliged to take their stand upon the grounds of actual experience. When the complete hollowness of their assumptions had been demonstrated, naturalists, in "the nation of thinkers," fell into the very opposite extreme, believing that they would be able to reach the high aim of science, that is, the knowledge of truth, by the mere experience of the senses, and without any philosophical activity of thought.

From that time, but especially since 1830, most naturalists have shown a strong aversion to any general, philosophical view of nature. The real aim of natural science was now supposed to consist in the knowledge of details, and it was believed that this would be attained in the study of biology, when the forms and the phenomena of life, in all individual organisms, had become accurately known, by the help of the

finest instruments and means of observation. It is true that among these strictly empirical, or so-called exact naturalists, there were always very many who rose above this narrow point of view, and sought the final aim in a knowledge of the general laws of organization. Yet the great majority of zoologists and botanists, during the thirty or forty years preceding Darwin, refused to concern themselves about such general laws; all they admitted was, that perhaps in the far distant future, when the end of all empiric knowledge should have been arrived at, when all individual animals and plants should have been thoroughly examined, naturalists might begin to think of discovering general biological laws.

If we consider and compare the most important advances which the human mind has made in the knowledge of truth, we shall soon see that it is always owing to philosophical mental operations that these advances have been made, and that the experience of the senses which certainly and necessarily precedes these operations, and the knowledge of details gained thereby, only furnish the basis for those general laws. Experience and philosophy, therefore, by no means stand in such exclusive opposition to each other as most men have hitherto supposed; they rather necessarily supplement each other. The philosopher who is wanting in the firm foundation of sensuous experience, of empirical knowledge, is very apt to arrive at false conclusions in his general speculations, which even a moderately informed naturalist can refute at once. On the other hand, the purely empiric naturalists, who do not trouble themselves about the philosophical comprehension of their sensuous experiences, and who do not strive after general knowledge, can promote science only in a very slight degree, and the chief value of

their hard-won knowledge of details lies in the general results which more comprehensive minds will one day derive from them.

From a general survey of the course of biological development since Linnæus' time, we can easily see, as Bär has pointed out, a continual vacillation between these two tendencies, at one time a prevalence of the empirical—the so-called exact—and then again of the philosophical or speculative tendency. Thus at the end of the last century, in opposition to Linnæus' purely empirical school, a natural-philosophical reaction took place, the moving spirits of which, Lamarck, Geoffroy St. Hilaire, Goethe, and Oken, endeavoured by their mental work to introduce light and order into the chaos of the accumulated empirical raw material. In opposition to the many errors and speculations of these natural philosophers, who went too far, Cuvier then came forward, introducing a second, purely empirical period. It reached its most one-sided development between the years 1830–1860, and there now followed a second philosophical reaction, caused by Darwin's work. Thus during the last ten years, men again have begun to endeavour to obtain a knowledge of the general laws of nature, to which, after all, all detailed knowledge of experience serves only as a foundation, and through which alone it acquires its true value. It is through philosophy alone that natural knowledge becomes a true science, that is, a philosophy of nature. (Gen. Morph. i. 63–108.)

Jean Lamarck and Wolfgang Goethe stand at the head of all the great philosophers of nature who first established a theory of organic development, and who are the illustrious fellow-workers of Darwin. I turn first to our beloved

Goethe, who, among all, stands in the closest relations to us Germans. However, before I explain his special services to the theory of development, it seems to me necessary to say a few words about his importance as a naturalist in general, as it is commonly very little known.

I am sure most of my readers honour Goethe only as a poet and a man; only a few have any conception of the high value of his scientific works, and of the gigantic stride with which he advanced before his own age—advanced so much that most naturalists of that time were unable to follow him. In several passages of his scientific writings he bitterly complains of the narrow-mindedness of professed naturalists, who do not know how to value his works (who cannot see the wood for the trees), and who cannot rouse themselves to discover the general laws of nature among the mass of details. He is only too just when he utters the reproach—"The philosophers will very soon discover that observers rarely rise to a stand-point from which they can survey so many important objects." It is true, at the same time, that their want of appreciation was caused by the false road into which Goethe was led in his theory of colours.

This theory of colours, which he himself designates as the favourite production of his leisure, however much that is beautiful it may contain, is a complete failure in regard to its foundations. The exact mathematical method by means of which alone it is possible, in inorganic sciences, but above all in physics, to raise a structure step by step on a thoroughly firm basis, was altogether repugnant to Goethe. In rejecting it he allowed himself not only to be very unjust towards the most eminent physicists, but to be led into errors which have greatly injured

the fame of his other valuable works. It is quite different in the organic sciences, in which we are but rarely able to proceed, from the beginning, upon a firm mathematical basis; we are rather compelled, by the infinitely difficult and intricate nature of the problem, at the first to form inductions—that is, we are obliged to endeavour to establish general laws by numerous individual observations, which are not quite complete. A comparison of kindred series of phenomena, or the method of combination, is here the most important instrument for inquiry, and this method was applied by Goethe with as much success as with conscious knowledge of its value, in his works relating to the philosophy of nature.

The most celebrated among Goethe's writings relating to organic nature is his *Metamorphosis of Plants*, which appeared in 1790, a work which distinctly shows a grasp of the fundamental idea of the theory of development, inasmuch as Goethe, in it, was labouring to point out a single organ, by the infinitely varied development and metamorphosis of which the whole of the endless variety of forms in the world of plants might be conceived to have arisen; this fundamental organ he found in the *leaf*. If at that time the microscope had been generally employed, if Goethe had examined the structure of organisms by the means of the microscope, he would have gone still further, and would have seen that the leaf is itself a compound of individual parts of a lower order, that is, of *cells*. He would then not have declared that the leaf, but that the *cell* is the real fundamental organ by the multiplication, transformation, and combination (synthesis) of which, in the first place, the leaf is formed; and that, in the next place, by transformation,

variation, and combination of leaves there arise all the varied beauties in form and colour which we admire in the green parts, as well as in the organs of propagation, or the flowers of plants. Goethe here showed that in order to comprehend the whole of the phenomena, we must in the first place compare them, and, secondly, search for a simple type, a simple fundamental form, of which all other forms are only infinite variations.

Something similar to what he had here done for the metamorphosis of plants he then did for the Vertebrate animals, in his celebrated *vertebral theory of the skull*. Goethe was the first to show, independently of Oken, who almost simultaneously arrived at the same thought, that the skull of man and of all Vertebrate animals, in particular mammals, is nothing more than a bony case, formed of the same bones,—that is, vertebræ,—out of which the spine also is composed. The vertebræ of the skull are like those of the spine, bony rings lying behind each other, but in the skull are peculiarly changed and specialized (differentiated). Although this idea has been strongly modified by recent discoveries, yet in Goethe's day it was one of the greatest advances in comparative anatomy, and was not only one of the first advances towards the understanding of the structure of Vertebrate animals, but at the same time explained many individual phenomena. When two parts of a body, such as the skull and spine, which appear at first sight so different, were proved to be parts originally the same, developed out of one and the same foundation, one of the difficult problems of the philosophy of nature was solved. Here again we meet the notion of a single type—the conception of a single principle, which becomes in-

finitely varied in the different species, and in the parts of individual species.

But Goethe did not merely endeavour to search for such far-reaching laws, he also occupied himself most actively for a long time with numerous individual researches, especially in comparative anatomy. Among these, none is perhaps more interesting than the discovery of the *mid jawbone in man*. As this is, in several respects, of importance to the theory of development, I shall briefly explain it here. There exist in all mammals two little bones in the upper jaw, which meet in the centre of the face, below the nose, and which lie between the two halves of the real upper jawbone. These two bones, which hold the four upper cutting teeth, are recognized without difficulty in most mammals; in man, however, they were at that time unknown, and celebrated comparative anatomists even laid great stress upon this want of a mid jawbone, as they considered it to constitute the principal difference between men and apes—the want of a mid jawbone was, curiously enough, looked upon as the most human of all human characteristics. But Goethe could not accept the notion that man, who in all other corporeal respects was clearly only a mammal of higher development, should lack this mid jawbone.

By the general law of induction as to the mid jawbone he arrived at the special deductive conclusion that it must exist in man also, and Goethe did not rest until, after comparing a great number of human skulls, he really found the mid jawbone. In some individuals it is preserved throughout a whole lifetime, but usually at an early age it coalesces with the neighbouring upper jawbone, and is

therefore only to be found as an independent bone in very youthful skulls. In human embryos it can now be pointed out at any moment. In man, therefore, the mid jawbone actually exists, and to Goethe the honour is due of having first firmly established this fact, so important in many respects; and this he did while opposed by the celebrated anatomist, Peter Camper, one of the most important professional authorities. The way by which Goethe succeeded in establishing this fact is especially interesting; it is the way by which we continually advance in biological science, namely, by way of induction and deduction. *Induction* is the inference of a general law from the observation of numerous individual cases; *deduction*, on the other hand, is an inference from this general law applied to a single case which has not yet been actually observed. From the collected empirical knowledge of those days, the inductive conclusion was arrived at that all mammals had mid jawbones. Goethe drew from this the deductive conclusion, that man, whose organization was in all other respects not essentially different from mammals, must also possess this mid jawbone; and on close examination it was actually found. The deductive conclusion was confirmed and verified by experience.

Even these few remarks may serve to show the great value which we must ascribe to Goethe's biological researches. Unfortunately most of his labours devoted to this subject are so hidden in his collected works, and his most important observations and remarks so scattered in numerous individual treatises—devoted to other subjects—that it is difficult to find them out. It also sometimes happens that an excellent, truly scientific remark is so

much interwoven with a mass of useless philosophical fancies, that the latter greatly detract from the former.

Nothing is perhaps more characteristic of the extraordinary interest which Goethe took in the investigation of organic nature than the lively way in which, even in his last years, he followed the dispute which broke out in France between Cuvier and Geoffroy de St. Hilaire. Goethe, in a special treatise which was only finished a few days before his death, in March, 1832, has given an interesting description of this remarkable dispute and its general importance, as well as an excellent sketch of the two great opponents. This treatise bears the title "*Principes de Philosophie Zoologique par M. Geoffroy de Saint Hilaire*"; it is Goethe's last work, and forms the conclusion of the collected edition of his works. The dispute itself was, in several respects, of the highest interest. It turned essentially upon the justification of the theory of development. It was carried on, moreover, in the bosom of the French Academy, by both opponents, with a personal vehemence almost unheard of in the dignified sessions of that learned body; this proved that both naturalists were fighting for their most sacred and deepest convictions. The conflict began on the 22nd of February, and was followed by several others; the fiercest took place on the 19th of July, 1830. Geoffroy, as the chief of the French nature-philosophers, represented the theory of natural development and the monistic conception of nature. He maintained the mutability of organic species, the common descent of the individual species from common primary forms, and the unity of their organization—or the unity of the plan of structure, as it was then called.

Cuvier was the most decided opponent of these views, and according to what we have seen, it could not be otherwise. He endeavoured to show that the nature-philosophers had no right to rear such comprehensive conclusions on the basis of the empirical knowledge then possessed, and that the unity of organization—or plan of structure of organisms—as maintained by them, did not exist. He represented the teleological (dualistic) conception of nature, and maintained that “the immutability of species was a necessary condition for the existence of a scientific history of nature.” Cuvier had the great advantage over his opponent, that he was able to bring towards the proof of his assertions things obvious to the eye; these, however, were only individual facts taken out of their connection with others. Geoffroy was not able to prove the higher and general connection of individual phenomena which he maintained, by equally tangible details. Hence Cuvier, in the eyes of the majority, gained the victory, and decided the defeat of the nature-philosophy and the supremacy of the strictly empiric tendency for the next thirty years.

Goethe of course supported Geoffroy's views. How deeply interested he was, even in his 81st year, in this great contest is proved by the following anecdote related by Soret :—

“Monday, Aug. 2nd, 1830.—The news of the outbreak of the revolution of July arrived in Weimar to-day, and has caused general excitement. In the course of the afternoon I went to Goethe. ‘Well?’ he exclaimed as I entered, ‘what do you think of this great event? The volcano has burst forth, all is in flames, and there are no more negotiations behind closed doors.’ ‘A dreadful affair,’ I answered;

‘but what else could be expected under the circumstances, and with such a ministry, except that it would end in the expulsion of the present royal family?’ ‘We do not seem to understand each other, my dear friend,’ replied Goethe. ‘I am not speaking of those people at all; I am interested in something very different, I mean the dispute between Cuvier and Geoffroy de Saint Hilaire, which has broken out in the Academy, and which is of such great importance to science.’ This remark of Goethe’s came upon me so unexpectedly, that I did not know what to say, and my thoughts for some minutes seemed to have come to a complete standstill. ‘The affair is of the utmost importance,’ he continued, ‘and you cannot form any idea of what I felt on receiving the news of the meeting on the 19th. In Geoffroy de Saint Hilaire we have now a mighty ally for a long time to come. But I see also how great the sympathy of the French scientific world must be in this affair, for, in spite of the terrible political excitement, the meeting on the 19th was attended by a full house. The best of it is, however, that the synthetic treatment of nature, introduced into France by Geoffroy, can now no longer be stopped. This matter has now become public through the discussions in the Academy, carried on in the presence of a large audience; it can no longer be referred to secret committees, or be settled or suppressed behind closed doors.’”

In my book on “The General Morphology of Organisms” I have placed as headings to the different books and chapters a selection of the numerous interesting and important sentences in which Goethe clearly expresses his view of organic nature and its constant development. I will here

quote a passage from the poem entitled, "The Metamorphosis of Animals" (1819).

"All members develop themselves according to eternal laws,
And the rarest form mysteriously preserves the primitive type.
Form therefore determines the animal's way of life,
And in turn the way of life powerfully reacts upon all form.
Thus the orderly growth of form is seen to hold
Whilst yielding to change from externally acting causes." *

Here, clearly enough, the contrast between two different organic constructive forms is intimated, which are opposed to one another, and which by their inter-action determine the form of the organism; on the one hand, a common inner original type, firmly maintaining itself, constitutes the foundation of the most different forms; on the other hand, the externally active influence of surroundings and mode of life, which influence the original type and transform it. This contrast is still more definitely pointed out in the following passage:—

"An inner original community forms the foundation of all organization; the variety of forms, on the other hand, arises from the necessary relations to the outer world, and we may therefore justly assume an original difference of conditions, together with an uninterruptedly progressive transformation, in order to be able to comprehend the constancy as well as the variations of the phenomena of form."

The "original type" which constitutes the foundation of

* Alle Glieder bilden sich aus nach ew'gen Gesetzen,
Und die seltenste Form bewahrt im Geheimniss das Urbild.
Also bestimmt die Gestalt die Lebensweise des Thieres.
Und die Weise zu leben, sie wirkt auf alle Gestalten
Mächtig zurück. So zeigt sich fest die geordnete Bildung,
Welche zum Wechsel sich neigt durch äusserlich wirkende Wesen.

every organic form "as the inner original community" is the *inner constructive force*, which receives the original direction of form-production—that is, the tendency to give rise to a particular form—and is propagated by *Inheritance*. The "uninterruptedly progressive transformation," on the other hand, which "springs from the necessary relations to the outer world," acting as an *external formative force*, produces, by *Adaptation* to the surrounding conditions of life, the "infinite variety of forms" (Gen. Morph. i. 154; ii. 224). The internal formative tendency of *Inheritance*, which retains the unity of the original type, is called by Goethe in another passage the *centripetal force* of the organism, or its tendency to specification; in contrast with this he calls the external formative tendency of *Adaptation*, which produces the variety of organic forms, the *centrifugal force* of organisms, or their tendency to variation. The passage in which he clearly indicates the "equilibrium" of these two extremely important organic formative tendencies, runs as follows: "The idea of *metamorphosis* resembles the vis centrifuga, and would lose itself in the infinite, if a counterpoise were not added to it: I mean the tendency to *specification*, the strong power to preserve what once has come into being, a vis centripeta, which in its deepest foundation cannot be affected by anything external."

Metamorphosis, according to Goethe, consists not merely, as the word is now generally understood, in the changes of form which the organic individual experiences during its individual development, but, in a wider sense, in the transformation of organic forms in general. His idea of metamorphosis is almost synonymous with the theory of development. This is clear, among other things, from the

following passage :—"The triumph of physiological metamorphosis manifests itself where the whole separates and transforms itself into families, the families into genera, the genera into species, and then again into other varieties down to the individual. This operation of nature goes on *ad infinitum* ; she cannot rest inactive, but neither can she keep and preserve all that she has produced. From seeds there are always developed varying plants, exhibiting the relations of their parts to one another in an altered manner."

Goethe had, in truth, discovered two great mechanical forces of nature, which are the active causes of organic formations, his two organic formative tendencies—on the one hand the conservative, centripetal, and internal formative tendency of Inheritance or specification ; and on the other hand the progressive, centrifugal, and external formative tendency of Adaptation, or metamorphosis. This profound biological intuition could not but lead him naturally to the fundamental idea of the Doctrine of Filiation, that is, to the conception that the organic species resembling one another in form are actually related by blood, and that they are descended from a common original type. In regard to the most important of all animal groups, namely that of Vertebrate animals, Goethe expresses this doctrine in the following passage (1796) :—"Thus much then we have gained, that we may assert without hesitation that all the more perfect organic natures, such as fishes, amphibious animals, birds, mammals, and man at the head of the last, were all formed upon one original type, which only varies more or less in parts which are none the less permanent, and still daily changes and modifies its form by propagation."

This sentence is of interest in more than one way. The

theory that all "the more perfect organic natures," that is all Vertebrate animals, are descended from one common prototype, that they have arisen from it by propagation (Inheritance) and transformation (Adaptation), may be distinctly inferred. But it is especially interesting to observe that Goethe admits no exceptional position for man, but rather expressly includes him in the tribe of the other Vertebrate animals. The most important special inference of the Doctrine of Filiation, that man is descended from other Vertebrate animals, may here be recognized in the germ.³

This exceedingly important fundamental idea is expressed by Goethe still more clearly in another passage (1807), in the following words:—"If we consider plants and animals in their most imperfect condition, they can scarcely be distinguished. But this much we can say, that the creatures which by degrees emerge as plants and animals out of a common phase, where they are barely distinguishable, arrive at perfection in two opposite directions; so that the plant in the end reaches its highest glory in the tree, which is immovable and stiff, the animal in man, who possesses the greatest elasticity and freedom." This remarkable passage not only indicates most explicitly the genealogical relationship between the vegetable and animal kingdoms, but contains the germ of the monophyletic hypothesis of descent, the importance of which I shall have to explain hereafter. (Compare Chapter XVI. and the Pedigree, vol. ii. pp. 74, 75.)

At the time when Goethe in this way sketched the fundamental features of the Theory of Descent, another German philosopher, Gottfried Reinhold Treviranus, of

Bremen (born 1776, died 1837), was zealously engaged at the same work. As Wilhelm Focke has recently shown, Treviranus, even in the earliest of his greater works, "The Biology or Philosophy of Animate Nature," which appeared at the beginning of the present century, had already developed monistic views of the unity of nature, and of the genealogical connection of the species of organisms, which entirely correspond with our present view of the matter. In the first three volumes of the Biology, which appeared successively in 1802, 1803, and 1805 (therefore several years before Oken's and Lamarck's principal works), we find numerous passages which are of interest in this respect. I shall here quote only a few of the most important.

In speaking of the principal question of our theory, the question of the origin of organic species, Treviranus makes the following remarks:—"Every form of life can be produced by physical forces in one of two ways: either by coming into being out of formless matter, or by modification of an already existing form by a continued process of shaping. In the latter case the cause of this modification may lie either in the influence of a dissimilar male generative matter upon the female germ, or in the influence of other powers which operate only after procreation. In every living being there exists the capability of an endless variety of form-assumption; each possesses the power to adapt its organization to the changes of the outer world, and it is this power put into action by the change of the universe that has raised the simple zoophytes of the primitive world to continually higher stages of organization, and has introduced a countless variety of species into animate nature."

By *zoophytes*, Treviranus here means organisms of the

lowest order and of the simplest character, namely, those neutral primitive beings which stand midway between animals and plants, and on the whole correspond with our *protista*. "These zoophytes," he remarks in another passage, "are the original forms out of which all the organisms of the higher classes have arisen by gradual development. We are further of opinion that every species, as well as every individual, has certain periods of growth, of bloom, and of decay, but that the decay of a species is *degeneration*, not dissolution, as in the case of the individual. From this it appears to us to follow that it was not the great catastrophies of the earth (as is generally supposed) which destroyed the animals of the primitive world, but that many survived them, and it is more probable that they have disappeared from existing nature, because the species to which they belonged have completed the circle of their existence, and have become changed into other kinds."

When Treviranus, in this and other passages, points to *degeneration* as the most important cause of the transformation of the animal and vegetable species, he does not understand by it what is now commonly called degeneration. With him "degeneration" is exactly what we now call *Adaptation* or *modification*, by the action of external formative forces. That Treviranus explained this transformation of organic species by Adaptation, and its preservation by Inheritance, and thus the whole variety of organic forms by the inter-action of Adaptation and Inheritance, is clear also from several other passages. How profoundly he grasped the mutual dependence of all living creatures on one another, and in general the *universal connection between cause and effect*—that is, the monistic

causal connection between all members and parts of the universe—is further shown, among others, by the following remarks in his *Biology*:—"The living individual is dependent upon the species, the species upon the fauna, the fauna upon the whole of animate nature, and the latter upon the organism of the earth. The individual possesses indeed a peculiar life, and so far forms its own world. But just because its life is limited it constitutes at the same time an organ in the general organism. Every living body exists in consequence of the universe, but the universe, on the other hand, exists in consequence of it."

It is self-evident that so profound and clear a thinker as Treviranus, in accordance with this grand mechanical conception of the universe, could not admit for man a privileged and exceptional position in nature, but assumed his gradual development from lower animal forms. And it is equally self-evident, on the other hand, that he did not admit a chasm between organic and inorganic nature, but maintained the absolute unity of the organization of the whole universe. This is specially attested by the following sentence:—"Every inquiry into the influence of the whole of nature on the living world must start from the principle, that all living forms are products of physical influences, which are acting even now, and are changed only in degree, or in their direction." Hereby, as Treviranus himself says, "The fundamental problem of biology is solved," and we add, solved in a purely mechanical or monistic sense.

Neither Treviranus nor Goethe is commonly considered the most eminent of the German nature-philosophers, but Lorenz Oken, who, in establishing the vertebral theory of the skull, came forward as a rival to Goethe, and did not

entertain a very kindly feeling towards him. Although they lived for some time in the same neighbourhood, yet the natures of these two men were so very different, that they could not well be drawn towards each other. Oken's "Manual of the Philosophy of Nature," which may be designated as the most important production of the nature-philosophy school then existing in Germany, appeared in 1809, the same year in which Lamarck's fundamental work, the "Philosophie Zoologique," was published. As early as 1802, Oken had published an "Outline of the Philosophy of Nature." As we have already intimated, in Oken's as in Goethe's works, a number of valuable and profound thoughts are hidden among a mass of erroneous, very eccentric, and fantastic conceptions. Some of these ideas have only quite recently and gradually become recognized in science, many years after they were first expressed. I shall here quote only two thoughts, which are almost prophetic, and which at the same time stand in the closest relation to the theory of development.

One of the most important of Oken's theories, which was formerly very much decried, and was most strongly combated, especially by the so-called "exact experimentalists," is the idea that the phenomena of life in all organisms proceed from a common chemical substance, so to say, from a general simple *vital-substance*, which he designated by the name *Urschleim*, or *original slime*. By it he meant, as the name indicates, a mucilaginous substance, an albuminous combination, which exists in a semi-fluid condition of aggregation, and possesses the power, by adaptation to different conditions of existence in the outer world and by interaction with its material, of producing the most various forms.

Now, we need only change the expression "original slime" (Urschleim) into *Protoplasm*, or *cell-substance*, in order to arrive at one of the grandest results which we owe to microscopic investigations during the last ten years, more especially to those of Max Schultze. By these investigations it has been shown that in all living bodies, without exception, there exists a certain quantity of mucilaginous albuminous matter, in a semi-fluid condition; and that this nitrogen-holding carbon-compound is exclusively the original seat and agent of all the phenomena of life, and of all production of organic forms. All other substances which appear in the organism, besides these, are either formed by this active matter of life, or have been introduced from without. The organic egg, the original cell out of which every animal and plant is first developed, consists essentially only of one round little lump of such albuminous matter. Even the yolk of an egg is nothing but albumen, mixed with granules of fat. Oken was therefore right when, more divining than knowing, he made the assertion—"Every organic thing has arisen out of slime, and is nothing but slime in different forms. This primitive slime originated in the sea, from inorganic matter in the course of planetary-evolution."

Another equally grand idea of the same philosopher is closely connected with his theory of primitive slime, which coincides with the extremely important *Protoplasm theory*. For Oken, as early as 1809, asserted that the primitive slime produced in the sea by spontaneous generation, at once assumed the form of microscopically small bladders, which he called "*Mile*," or "*Infusoria*." "Organic nature has for its basis an infinity of such vesicles." These little

bladders arise from original semi-fluid globules of the primitive slime, by the fact of their periphery becoming condensed. The simplest organism, as well as every animal and every plant of higher kind, is nothing else than "an accumulation (synthesis) of such infusorial bladders, which by various combinations assume various forms, and thus develop into higher organisms." Here again we need only translate the expression *little bladder*, or *infusorium*, by the word *cell*, and we arrive at the Cell theory, one of the grandest biological theories of our century. Schleiden and Schwann, about thirty years ago, were the first to furnish experiential proof that all organisms are either simple cells, or accumulations (syntheses) of such cells, and the more recent protoplasm theory has shown that protoplasm (the original slime) is the most essential (and sometimes the only) constituent part of the genuine cell. The properties which Oken ascribes to his Infusoria are exactly the properties of cells, the properties of elementary beings, by whose accumulation, combination, and varying development, the higher organisms are formed.

These two extremely fruitful thoughts of Oken, on account of the absurd form in which he expressed them, were at first little heeded, or entirely misunderstood, and it was reserved for a much later era to establish them by actual observation. The supposition that the individual species of plants and animals originated from common prototypes by a slow and gradual development of the higher organisms out of lower ones, was of course most closely connected with these ideas. Man's descent from lower organisms was likewise asserted by Oken—"Man has been developed, not created." Although many arbitrary perversities and ex-

travagant fancies may be found in Oken's philosophy of nature, they must not prevent us paying our just admiration to these grand ideas, which were so far in advance of their age. This much is clearly evident from the statements of Goethe and Oken which we have quoted, and from the views of Lamarck and Geoffroy which have to be discussed next, that during the first decade of our century no doctrine approached so nearly to the natural Theory of Descent, newly established by Darwin, as the much decried "Natur-philosophie."

CHAPTER V.

THEORY OF DEVELOPMENT ACCORDING TO KANT
AND LAMARCK.

Kant's Dualistic Biology.—His Conception of the Origin of Inorganic Nature by Mechanical Causes, of Organic Nature by Causes acting for a Definite Purpose.—Contradiction of this Conception with his leaning towards the Theory of Descent.—Kant's Genealogical Theory of Development.—Its Limitation by his Teleology.—Comparison of Genealogical Biology with Comparative Philology.—Views in favour of the Theory of Descent entertained by Leopold Buch, Bär, Schleiden, Unger, Schaafhausen, Victor Carus, Büchner. — French Nature-philosophy. — Lamarck's *Philosophie Zoologique*. — Lamarck's Monistic (mechanical) System of Nature.—His Views of the Inter-action of the Two Organic Formative Tendencies of Inheritance and Adaptation.—Lamarck's Conception of Man's Development from Ape-like Mammals. — Geoffroy St. Hilaire's, Naudin's, and Lecoq's Defence of the Theory of Descent.—English Nature-philosophy.—Views in favour of the Theory of Descent, entertained by Erasmus Darwin, W. Herbert, Grant, Freke, Herbert Spencer, Hooker, Huxley.—The Double Merit of Charles Darwin.

THE teleological view of nature, which explains the phenomena of the organic world by the action of a personal Creator acting for a definite purpose, necessarily leads, when carried to its extreme consequences, either to utterly untenable contradictions, or to a twofold (dualistic) conception of nature, which most directly contradicts the unity and simplicity of the supreme laws which are everywhere perceptible. The philosophers who embrace teleology must

necessarily assume two fundamentally different natures : an *inorganic* nature, which must be explained by causes acting *mechanically* (causæ efficientes), and an *organic* nature, which must be explained by *causes acting for a definite purpose* (causæ finales). (Compare p. 34.)

This dualism meets us in a striking manner when considering the conceptions of nature formed by Kant, one of the greatest German philosophers, and his ideas of the coming into being of organisms. A closer examination of these ideas is forced upon us here, because in Kant we honour one of the few philosophers who combine a solid scientific culture with an extraordinary clearness and profundity of speculation. The Königsberg philosopher gained the highest celebrity, not only among speculative philosophers as the founder of critical philosophy, but acquired a brilliant name also among naturalists by his mechanical cosmogeny. Even in the year 1755, in his "General History of Nature, and Theory of the Heavens,"²² he made the bold attempt "to discuss the constitution and the mechanical origin of the whole universe, according to Newton's principles," and to explain them mechanically by the natural course of development, to the exclusion of all miracles. This cosmogeny of Kant, or "cosmological gas theory," which we shall briefly discuss in a future chapter, was at a later day fully established by the French mathematician Laplace and the English astronomer Herschel, and enjoys at the present day almost universal recognition. On account of this important work alone, in which exact knowledge is coupled with most profound speculation, Kant deserves the honourable name of a natural philosopher in the best and purest sense of the word.

If we read Kant's Criticism of the Teleological Faculty of Judgment, his most important biological work, we perceive that in contemplating organic nature he always maintains what is essentially the teleological or dualistic point of view; whilst for inorganic nature he, unconditionally and without reserve, assumes the mechanical or monistic method of explanation. He affirms that in the domain of inorganic nature all the phenomena can be explained by mechanical causes, by the moving forces of matter itself, but not so in the domain of organic nature. In the whole of Anorganology (in Geology and Mineralogy, in Meteorology and Astronomy, in the physics and chemistry of inorganic natural bodies), all phenomena are said to be explicable merely by *mechanism* (*causa efficiens*), without the intervention of a final purpose. In the whole domain of Biology, on the other hand—in Botany, Zoology, and Anthropology—mechanism is not considered sufficient to explain to us all their phenomena; but we are supposed to be able to comprehend them only by an assumption of a *final cause* acting for a definite purpose (*causa finalis*). In several passages Kant emphatically remarks that, from a strictly scientific point of view, *all* phenomena, without exception, require a mechanical interpretation, and that *mechanism alone can offer a true explanation*. But at the same time he thinks, that in regard to living natural bodies, animals and plants, our human power of comprehension is limited, and not sufficient for arriving at the real cause of organic processes, especially at the origin of organic forms. The *right* of human reason to explain all phenomena mechanically is unlimited, he says, but its *power* is limited by the fact that organic nature can be conceived only from a teleological point of view.

Some passages are, however, very remarkable, in which Kant in a surprising manner deviates from this mode of viewing things, and expresses, more or less distinctly, the fundamental idea of the Theory of Descent. He even asserts the necessity of a genealogical conception of the series of organisms, if we at all wish to understand it scientifically. The most important and remarkable of these passages occurs in his "Methodical System of the Teleological Faculty of Judgment" (§ 79), which appeared in 1790 in the "Criticism of the Faculty of Judgment." Considering the extraordinary interest which this passage possesses, both for forming a correct estimate of Kant's philosophy, as well as for the Theory of Descent, I shall here insert it *verbatim*.

"It is desirable to examine the great domain of organized nature by means of a methodical comparative anatomy, in order to discover whether we may not find in it something resembling a system, and that too in connection with the mode of generation, so that we may no longer be compelled to stop short with a mere consideration of forms as they are—which gives us no insight into their generation—and need no longer give up in despair all hope of gaining a full insight into this department of nature. The agreement of so many kinds of animals in a certain common plan of structure, which seems to be visible not only in their skeletons, but also in the arrangement of the remaining parts—so that a wonderfully simple typical form, by the shortening and lengthening of some parts, and by the suppression and development of others, might be able to produce an immense variety of species—gives us a ray of hope, though feeble, that here perhaps some result may be obtained, by the application of the principle of the *mechanism of nature*, without which,

in fact, no science can exist. This analogy of forms (in so far as they seem to have been produced in accordance with a common prototype, notwithstanding their great variety) strengthens the supposition that they have an actual blood-relationship, due to origination from a common parent; a supposition which is arrived at by observation of the graduated approximation of one class of animals to another, beginning with the one in which the principle of purposiveness seems to be most conspicuous, that is man, and extending down to the polyyps, and from these even down to mosses and lichens, and arriving finally at raw matter, the lowest stage of nature observable by us. From this matter and its forces the whole apparatus of Nature seems to have descended according to mechanical laws (such as those which she follows in the production of crystals); yet this apparatus, as seen in organic beings, is so incomprehensible to us, that we feel ourselves compelled to conceive for it a different principle. But it would seem that the archæologist of Nature is at liberty to regard the great *Family* of creatures (for as a Family we must conceive it, if the above-mentioned continuous and connected relationship has a real foundation) as having sprung from the immediate results of her earliest revolutions, judging from all the laws of their mechanism known to or conjectured by him."

If we take this remarkable passage out of Kant's "Criticism of the Teleological Faculty of Judgment," and consider it by itself, we cannot but be astonished to find how profoundly and clearly the great thinker, even in 1790, had recognized the inevitable necessity of the Doctrine of Descent, and designated it as the only possible way of explaining organic nature by mechanical laws—that is, by

true scientific reasoning. On account of this one passage taken by itself, we might place Kant beside Goethe and Lamarck, as one of the first founders of the Doctrine of Descent; and considering the high authority which Kant's Critical Philosophy most justly enjoys, this circumstance might perhaps induce many a philosopher to decide in favour of the theory. But as soon as we consider this passage in connection with the other train of thoughts in the "Criticism of the Faculty of Judgment," and balance it against other directly contradictory passages, we see clearly that Kant, in these and some similar (but weaker) sentences, went beyond himself, and abandoned the teleological point of view which he usually adopts in Biology.

Directly after the admirable passage which I have just quoted, there follows a remark which completely takes off its edge. After having quite correctly maintained the origin of organic forms out of raw matter by mechanical laws (in the manner of crystallization), as well as a gradual development of the different species by descent from one common original parent, Kant adds, "But he (the archæologist of nature, that is the palæontologist) must for this end ascribe to the common mother an organization ordained purposely with a view to the needs of all her offspring, otherwise the possibility of suitability of form in the products of the animal and vegetable kingdoms (*i.e.* teleological adaptation) cannot be conceived at all." This addition clearly contradicts the most important fundamental thought of the preceding passage, viz. that a purely mechanical explanation of organic nature becomes possible through the Theory of Descent. And that the teleological conception of organic nature predominated with Kant, is shown by

the heading of the remarkable § 79, which contains the two contradictory passages cited: "*Of the Necessary Subordination of the Mechanical to the Teleological Principle, in the explanation of a thing as a purpose or object of Nature.*"

He expresses himself most decidedly against the mechanical explanation of organic nature in the following passage (§ 74): "It is quite certain that we cannot become sufficiently acquainted with organized creatures and their hidden potentialities by aid of purely mechanical natural principles, much less can we explain them; and this is so certain, that we may boldly assert that it is absurd for man even to conceive such an idea, or to hope that a Newton may one day arise able to make the production of a blade of grass comprehensible, according to natural laws ordained by no intention; such an insight we must absolutely deny to man." Now, however, this impossible Newton has really appeared seventy years later in Darwin, whose Theory of Selection has actually solved the problem, the solution of which Kant had considered absolutely inconceivable!

In connection with Kant and the German philosophers whose theories of development have already occupied us in the preceding chapter, it seems justifiable to consider briefly some other German naturalists and philosophers, who, in the course of our century, have more or less distinctly resisted the prevailing teleological views of creation, and vindicated the mechanical conception of things which is the basis of the Doctrine of Filiation. Sometimes general philosophical considerations, sometimes special empirical observations, were the motives which led these thinking men to form the idea that the various individual species of organisms must have originated from common primary forms. Among them

I must first mention the great German geologist, Leopold Buch. Important observations as to the geographical distribution of plants led him to the following remarkable assertion in his excellent "Physical Description of the Canary Islands":—

"The individuals of genera, on continents, spread and widely diffuse themselves, and by the difference of localities, nourishment, and soil, form varieties; and being in consequence of their isolation never crossed by other varieties, and so brought back to the main type, they in the end become a permanent and a distinct species. Then, perhaps, in other ways, they once more become associated with other descendants of the original form—which have likewise become new varieties—and both now appear as very distinct species, no longer mingling with one another. Not so on islands. Being commonly confined in narrow valleys or within the limit of small zones, individuals can reach one another and destroy every commencing production of a permanent variety. Much in the same way the peculiarities or faults in language, originating with the head of some family, become, through the extension of the family, indigenous throughout a whole district. If the district is separated and isolated, and if the language is not brought back to its former purity by constant connection with that spoken in neighbouring districts, a dialect will be the result. If natural obstacles, forests, constitution, form of government, unite the inhabitants of the separate district still more closely, and separate them still more completely from their neighbours, the dialect is fixed, and becomes a completely distinct language." (Uebersicht der Flora auf den Canarien, S. 133.)

We perceive that Buch is here led to the fundamental idea of the Theory of Descent by the phenomena of the geography of plants, a department of biological knowledge which in fact furnishes a mass of proofs in favour of it. Darwin has minutely discussed these proofs in two separate chapters of his book (the 11th and 12th). Buch's remark is further of interest, because it leads us to the exceedingly instructive comparison of the different branches of language with the species of organisms, a comparison which is of the greatest use to Comparative Philology, as well as to Comparative Botany and Zoology. Just as, for example, the different dialects, provincialisms, branches, and off-shoots of the German, Slavonic, Greco-Latin, and Irano-Indian parent language, are derived from a single common Indo-Germanic parent tongue, and just as their *differences* are explained by *Adaptation*, and their common *fundamental characters* explained by *Inheritance*, so in like manner the different species, genera, families, orders, and classes of Vertebrate animals are derived from a single common vertebrate form of animal. Here also Adaptation is the cause of differences, Inheritance the cause of community of character. This interesting parallelism in the divergent development of the forms of speech and the forms of organisms has been discussed in the clearest manner by one of our first comparative philologists, the talented Augustus Schleicher, whose premature death, four years ago, remains an irreparable loss, not only to our University of Jena, but to the whole of monistic science.⁶

Among other eminent German naturalists who have expressed their belief in the Theory of Descent more or less distinctly, arriving at their conclusion in very various ways,

I must next mention Carl Ernst Bär, the great reformer of animal embryology. In a lecture delivered in 1834, entitled "The Most General Laws of Nature in All Development," he shows, in the clearest way, that only in a very childish view of nature could organic species be regarded as permanent and unchangeable types, and that really they can be only passing series of generations, which have developed by transformation from a common original form. The same conception again received firm support from Baer, in 1859, through a consideration of the of laws the geographical distribution of organisms.

J. M. Schleiden, who founded, thirty years ago, in Jena, a new epoch in Botany by his strictly empirico-philosophical and truly scientific method, illustrated the philosophical significance of the conception of organic species in his incisive "Outlines of Scientific Botany,"⁷ and showed that it had only a subjective origin in the general *law of specification*. The different species of plants are only the specified productions of the formative tendencies of plants, which arise from the various combinations of the fundamental forces of organic matter.

The eminent botanist, F. Unger, of Vienna, was led by his profound and comprehensive investigations on extinct vegetable species, to a palæontological history of the development of the vegetable kingdom, which distinctly asserts the principle of the Theory of Descent. In his "Attempt at a History of the World of Plants" (1852), he maintains the derivation of all different species of plants from a few primary forms, and perhaps from a single original plant, a simple vegetable cell. He shows that this view is founded on the genetic connection of all vegetable forms, and is

necessary, not merely upon philosophical grounds, but upon those of experience and observation.⁸

Victor Carus, of Leipzig, in the Introduction to his excellent "System of Animal Morphology,"⁹ published in 1853, in which he endeavours to establish in a philosophical manner the universal constructive laws of the animal body through comparative anatomy and the history of development, makes the following remark :—"The organisms buried in the most ancient geological strata must be looked upon as the ancestors from whom the rich diversity of forms of the present creation have originated by continued generation, and by accommodation to progressive and very different conditions of life."

In the same year (1853) Schaaffhausen, the anthropologist of Bonn, in an Essay "On the Permanence and Transformation of Species," declared himself decidedly in favour of the Theory of Descent. According to him, the living species of animals and plants are the transformed descendants of extinct species, from which they have arisen by gradual modification. The divergence or separation of the most nearly allied species takes place by the destruction of the connecting intermediate stages. Schaaffhausen also maintained, with distinctness, the origin of the human race from animals, and its gradual development from ape-like animals, the most important deduction from the Doctrine of Filiation.

Lastly, we have still to mention among the German Nature-philosophers the name of Louis Büchner, who, in his celebrated work, "Force and Matter" (1855), also independently developed the principles of the Theory of Descent, taking his stand mainly on the ground of the undeniable evidences of fact which are furnished by the palæontological and in-

dividual development of organisms, as well as by their comparative anatomy and by the parallelism of these series of development. Büchner showed very clearly that, even from such data alone, the derivation of the different organic species from common primary forms followed as a necessary conclusion, and that the origin of these original primary forms could only be conceived of as the result of a spontaneous generation.

We now turn from the German to the French Nature-philosophers, who have likewise held the Theory of Descent, since the beginning of the present century. At their head stands Jean Lamarek, who occupies the first place next to Darwin and Goethe in the history of the Doctrine of Filiation. To him will always belong the immortal glory of having for the first time worked out the Theory of Descent, as an independent scientific theory of the first order, and as the philosophical foundation of the whole science of Biology. Although Lamarek was born as early as 1744, he did not begin the publication of his theory until the commencement of the present century, in 1801, and established it more fully only in 1809, in his classic "*Philosophie Zoologique*."² This admirable work is the first connected exposition of the Theory of Descent carried out strictly into all its consequences. By its purely mechanical method of viewing organic nature, and the strictly philosophical proofs brought forward in it, Lamarek's work is raised far above the prevailing dualistic views of his time; and with the exception of Darwin's work, which appeared just half a century later, we know of none which we could in this respect place by the side of the "*Philosophie Zoologique*." How far it was in advance of its time is perhaps best seen from the cir-

cumstance that it was not understood by most men, and for fifty years was not spoken of at all. Cuvier, Lamarck's greatest opponent, in his "Report on the Progress of Natural Sciences," in which the most unimportant anatomical investigations are enumerated, does not devote a single word to this work, which forms an epoch in science. Goethe, also, who took such a lively interest in the French nature-philosophy and in "the thoughts of kindred minds beyond the Rhine," nowhere mentions Lamarck, and does not seem to have known the "Philosophie Zoologique" at all. The great reputation which Lamarck gained as a naturalist he does not owe to his highly important general work, but to numerous special treatises on the lower animals, particularly on Molluscs, as well as to an excellent "Natural History of Invertebrate Animals," which appeared, in seven volumes, between the years 1815-1822. The first volume of this celebrated work contains in the general introduction a detailed exposition of his theory of filiation. I can, perhaps, give no better idea of the extraordinary importance of the "Philosophie Zoologique" than by quoting *verbatim* some of the most important passages therefrom:—

"The systematic divisions of classes, orders, families, genera, and species, as well as their designations, are the arbitrary and artificial productions of man. The kinds or species of organisms are of unequal age, developed one after the other, and show only a relative and temporary persistence; species arise out of varieties. The differences in the conditions of life have a modifying influence on the organization, the general form, and the parts of animals, and so has the use or disuse of organs. In the first beginning only the very simplest and lowest animals and plants came into

existence ; those of a more complex organization only at a later period. The course of the earth's development, and that of its organic inhabitants, was continuous, not interrupted by violent revolutions. Life is purely a physical phenomenon. All the phenomena of life depend on mechanical, physical, and chemical causes, which are inherent in the nature of matter itself. The simplest animals and the simplest plants, which stand at the lowest point in the scale of organization, have originated and still originate by spontaneous generation. All animate natural bodies or organisms are subject to the same laws as inanimate natural bodies or anorgana. The ideas and actions of the understanding are the motional phenomena of the central nervous system. The will is in truth never free. Reason is only a higher degree of development and combination of judgments."

These are indeed astonishingly bold, grand, and far-reaching views, and were expressed by Lamarck sixty years ago ; in fact, at a time when their establishment, by a mass of facts, was not nearly as possible as it is in our day. Indeed Lamarck's work is really a complete and strictly monistic (mechanical) system of nature, and all the important general principles of monistic Biology are already enunciated by him : the unity of the active causes in organic and inorganic nature ; the ultimate explanation of these causes in the chemical and physical properties of matter itself ; the absence of a special vital power, or of an organic final cause ; the derivation of all organisms from some few, most simple original forms, which have come into existence by spontaneous generation out of inorganic matter ; the coherent course of the whole earth's history ; the absence of

violent cataclysmic revolutions ; and in general the inconceivableness of any miracle, of any supernatural interference, in the natural course of the development of matter.

The fact that Lamarck's wonderful intellectual feat met with scarcely any recognition, arises partly from the immense length of the gigantic stride with which he had advanced beyond the next fifty years, partly from its defective empirical foundation, and from the somewhat one-sided character of some of his arguments. Lamarck quite correctly recognizes *Adaptation* as the first mechanical cause which effects the continual transformation of organic forms, while he traces with equal justice the similarity in form of different species, genera, families, etc., to their blood-relationship, and thus explains it by *Inheritance*. Adaptation, according to him, consists in this, that the perpetual, slow change of the outer world causes a corresponding change in the actions of organisms, and thereby also causes a further change in their forms. He lays the greatest stress upon the effect of *habit* upon the use and disuse of organs. This is certainly of great importance in the transformation of organic forms, as we shall see later. However, the way in which Lamarck wished to explain exclusively, or at any rate mainly, the change of forms, is after all in most cases not possible. He says, for example, that the long neck of the giraffe has arisen from its constantly stretching out its neck at high trees, and from the endeavour to pick the leaves off their branches ; as giraffes generally inhabit dry districts, where only the foliage of trees afford them nourishment, they were forced to this action. In like manner the long tongues of woodpeckers, humming-birds, and ant-eaters, are said by him to

have arisen from the habit of fetching their food out of narrow, small, and deep crevices or channels. The webs between the toes of the webbed feet in frogs and other aquatic animals have arisen solely from the constant endeavour to swim, from striking their feet against the water, and from the very movements of swimming. Inheritance fixed these habits on the descendants, and finally, by further elaboration, the organs were entirely transformed. However correct, as a whole, this fundamental thought may be, yet Lamarck lays the stress too exclusively on *habit* (use and non-use of organs), certainly one of the most important, but not the only cause of the change of forms. Still this cannot prevent our acknowledging that Lamarck quite correctly appreciated the mutual co-operation of the two organic formative tendencies of Adaptation and Inheritance. What he failed to grasp is the exceedingly important principle of "Natural Selection in the Struggle for Existence," with which Darwin, fifty years later, made us acquainted.

It still remains to be mentioned as a special merit of Lamarck, that he endeavoured to prove the *development of the human race* from other primitive, ape-like mammals. Here again it was, above all, to habit that he ascribed the transforming, the ennobling influence. He assumed that the lowest, original men had originated out of men-like apes, by the latter accustoming themselves to walk upright. The raising of the body, the constant effort to keep upright, in the first place led to a transformation of the limbs, to a stronger differentiation or separation of the fore and hinder extremities, which is justly considered one of the most essential distinctions between man and the ape. Behind, the calf of the leg and the flat soles of the feet were

developed ; in front, the arms and hands, for the purpose of seizing objects. The upright walk was then followed by a freer view over the surrounding objects, and led consequently to an important progress in mental development. Human apes thereby soon gained a great advantage over the other apes, and further, over surrounding organisms in general. In order to maintain the supremacy over them, they formed themselves into companies, and there arose, as in the case of all animals living in company, the desire of communicating to one another their desires and thoughts. Thus arose the necessity of language, which, consisting at first of rough and disjointed sounds, soon became more connected, developed, and articulate. The development of articulate speech now in turn became the strongest lever for a further progressive development of the organism, and above all, of the brain, and so ape-like men became gradually and slowly transformed into real men. In this way the actual descent of the lowest and rudest primitive men from the most highly developed apes was distinctly maintained by Lamarck, and supported by a series of the most important proofs.

The honour of being the chief French nature-philosopher is not usually assigned to Lamarck, but to Etienne Geoffroy St. Hilaire (the elder), born in 1771, the same in whom Goethe was especially interested, and with whom we have already become acquainted as Cuvier's most prominent opponent. He developed his ideas about the transformation of organic species as far back as the end of the last century, but published them only in the year 1828, and then in the following years, especially in 1830, defended them bravely against Cuvier. Geoffroy St. Hilaire in all essentials adopted Lamarck's Theory of Descent, yet he believed that

the transformation of animal and vegetable species was less effected by the action of the organism itself (by habit, practice, use, or disuse of organs) than by the "monde ambiant," that is, by the continual change of the outer world, especially of the atmosphere. He conceives the organism as passive, in regard to the vital conditions of the outer world, while Lamarck, on the contrary, regards it as active. Geoffroy thinks, for example, that birds originated from lizard-like reptiles, simply by a diminution of the carbonic acid in the atmosphere, in consequence of which the breathing process became more animated and energetic through the increased proportion of oxygen in the atmosphere. Thus there arose a higher temperature of the blood, an increased activity of the nerves and muscles, and the scales of the reptiles became the feathers of the birds, etc. This conception is based upon a correct thought, but although the change of the atmosphere, as well as the change of every other external condition of existence, certainly effects directly or indirectly the transformation of the organism, yet this single cause is by itself too unimportant for such effects to be ascribed to it. It is even less important than practice and habit, upon which Lamarck lays too much stress. Geoffroy's chief merit consists in his having vindicated the monistic conception of nature, the unity of organic forms, and the deep genealogical connection of the different organic types in the face of Cuvier's powerful influence. I have already mentioned in the preceding chapter (pp. 87, 88) the celebrated disputes between the two great opponents in the Academy of Paris, especially the fierce conflicts on the 22nd of February, and on the 19th of July, in which Goethe took so lively an interest. On that

occasion Cuvier remained the acknowledged victor, and since that time very little, or rather nothing, more has been done in France to further the development of the Doctrine of Filiation, and complete the monistic theory of development. This is evidently to be ascribed principally to the repressive influence exercised by Cuvier's great authority. Even at the present day the majority of the French naturalists are the disciples and blind followers of Cuvier. In no civilized country of Europe has Darwin's doctrine had so little effect and been so little understood as in France, so that in the further course of our examination we need not take the French naturalists into consideration. At most, there are two distinguished botanists, among the recent French naturalists, whom we may mention as having ventured to express themselves in favour of the mutability and transformation of species. These two men are Naudin (1852) and Lecoq (1854).

Having discussed the early services of German and French nature-philosophy in establishing the doctrine of descent, we turn to the third great country of Europe, to free England, which during the last ten years has become the chief seat and starting-point for the further working out and definite establishment of the theory of development. Englishmen, who now take such an active part in every great scientific progress of humanity, and are the first to promote the eternal truths of natural science, at the beginning of the century took but little part in the continental nature-philosophy and its most important progress, the Theory of Descent. Almost the only earlier English naturalist whom we have here to mention is Erasmus Darwin, the grandfather of the reformer of the Theory of

Descent. In 1795 he published, under the title of "Zoonomia," a scientific work in which he expresses views very similar to those of Goethe and Lamarck, without, however, then knowing anything about these two men. It is evident that the Theory of Descent at that time pervaded the intellectual atmosphere. Erasmus Darwin lays great stress upon the transformation of animal and vegetable species by their own vital action and by their becoming accustomed to changed conditions of existence, etc. Next, W. Herbert, in 1822, expressed the opinion that species of animals and plants are nothing but varieties which have become permanent. In like manner Grant, in Edinburgh, in 1826, declared that new species proceed from existing species by continued transformation. In 1841 Freke maintained that all organic beings must be descended from a single primitive type. In 1852 Herbert Spencer demonstrated minutely, and in a very clear and philosophic manner, the necessity of the Doctrine of Filiation, and established it more firmly in his excellent "Essays," which appeared in 1858, and in his "Principles of Biology," which was published at a later date. He has, at the same time, the great merit of having applied the theory of development to psychology, and of having shown that the emotional and intellectual faculties could only have been acquired by degrees and developed gradually. Lastly, we have to mention that in 1859 Huxley, the first of English zoologists, spoke of the Theory of Descent as the only hypothesis of creation reconcilable with scientific physiology. The same year produced the "Introduction to the Flora of Tasmania," in which Hooker, the celebrated English botanist, adopts the Theory of Descent, supporting it with important observations of his own.

All the naturalists and philosophers with whom we have become acquainted in this brief historical survey, as men adopting the Theory of Development, merely arrived at the conception that all the different species of animals and plants which at any time have lived, and still live, upon the earth, are the gradually changed and transformed descendants of one or some few original and very simple prototypes, which latter arose out of inorganic matter by spontaneous generation. But none of them succeeded in placing this fundamental element of the doctrine of descent in relation with some cause, nor in satisfactorily explaining the transformation of organic species by the true demonstration of its mechanical antecedents. Charles Darwin was the first who solved this most difficult problem, and this forms the broad gulf which separates him from his predecessors.

The special merit of Charles Darwin is, in my opinion, twofold: in the first place, the doctrine of descent, the fundamental idea of which was already clearly expressed by Goethe and Lamarck, has been developed by him much more comprehensively, has been traced much more minutely in all directions, and carried out much more strictly and connectedly than by any of his predecessors; and secondly, he has established a new theory, which reveals to us the natural causes of organic development, the acting causes (*causæ efficientes*) of organic form-production, and of the changes and transformations of animal and vegetable species. This is the theory which we call the Theory of Selection, or more accurately, the Theory of Natural Selection (*selectio naturalis*).

When we reflect that (with the few exceptions above men-

tioned) the whole science of Biology, before Darwin's time, was elaborated in accordance with the opposite views, and that almost all zoologists and botanists regarded the absolute independence of organic species as a self-evident inference from the results of all study of forms, we shall certainly not lightly value the twofold merit of Darwin. The false doctrine of the constancy and independent creation of individual species had gained such high authority, was so generally recognized, and was, moreover, so much favoured by delusive appearances, accepted by superficial observation, that, indeed, no small degree of courage, strength, and intelligence was required to rise as a reformer against its omnipotence, and to dash to pieces the structure artificially erected upon it. But, in addition to this, Darwin added to Lamarck's and Goethe's doctrine of descent the new and highly important principle of "natural selection."

We must sharply distinguish the two points—though this is usually not done—first, Lamarck's Theory of Descent, which only asserts *that* all animal and vegetable species are descended from common, most simple, and spontaneously generated prototypes; and secondly, Darwin's Theory of Selection, which shows us *why* this progressive transformation of organic forms took place, and what causes, acting mechanically, effected the uninterrupted production of new forms, and the ever increasing variety of animals and plants.

Darwin's immortal merit cannot be justly estimated until a later period, when the Theory of Development, after overthrowing all other theories of creation, will be recognized as the supreme principle of explanation in Anthropology, and, consequently, in all other sciences. At present, while in

the hot contest for truth the name of Darwin is the watchword to the advocates of the natural theory of development, his merits are inaccurately appreciated on both sides, for some persons overestimate them as much as others underestimate them.

His merit is overestimated when he is regarded as the founder of the Theory of Descent, or of the whole of the Theory of Development. We have seen from the historical sketch in this and the preceding chapters, that the Theory of Development, as such, is not new; all philosophers who have refused to be led captive by the blind dogma of a supernatural creation, have been compelled to assume a natural development. But the Theory of Descent constituting the specially biological part of the universal Theory of Development, had already been so clearly expressed by Lamarck, and carried out so fully by him to its most important consequences, that we must honour him as the real founder of it. Hence it is only the Theory of Selection, and not that of Descent, which may be called *Darwinism*; but this is in itself of so much importance, that its value can scarcely be overestimated.

Darwin's merit is naturally underestimated by all his opponents. But it is scarcely possible in this matter to point to scientific opponents, who are entitled by profound biological culture to pronounce an opinion. For among all the works opposed to Darwin and the Theory of Descent yet published, with the exception of that of Agassiz, not one deserves consideration, much less refutation; all have so evidently been written either without thorough knowledge of biological facts, or without a clear philosophical understanding of the question in hand. We need not trouble

ourselves at all about the attacks of theologians and other unscientific men, who really know nothing whatever of nature.

The only eminent scientific adversary who still remains opposed to Darwin and the whole theory of development is Louis Agassiz; but the principle of his opposition in reality deserves notice only as a philosophical curiosity. In a French translation of his "Essay on Classification,"⁵ which we have spoken of before, published in Paris in 1869, Agassiz has most formally announced his opposition to Darwinism, which he had previously expressed in many ways. To this translation he has appended a treatise of sixteen pages, bearing the title, "Le Darwinisme. Classification de Haeckel." This curious chapter contains the most wonderful things; as, for example, "Darwin's idea is a conception *à priori*. Darwinism is a burlesque of facts. Science would renounce the claim which it has hitherto possessed to the confidence of earnest minds if such sketches were to be accepted as indications of a true progress." The following passage, however, is the climax of this strange polemic: "Darwinism shuts out almost the whole mass of acquired knowledge in order to retain and assimilate to itself that only which may serve its doctrine."

Surely this is what we may call turning the whole affair topsy-turvy! The biologist who knows the facts must be astounded at Agassiz's courage in uttering such sentences—sentences without a word of truth in them, and which he cannot himself believe! The impregnable strength of the Theory of Descent lies just in the fact that all biological facts are explicable only through it, and that without it they remain unintelligible miracles. All our "laborious knowledge" in comparative anatomy and physiology—in

embryology and palæontology—in the doctrine of the geographical and topographical distribution of organisms, etc., constitutes an irrefutable testimony to the truth of the Theory of Descent.

In my General Morphology, especially in the sixth book (in the General Phylogeny), I have minutely refuted Agassiz's "Essay on Classification" in all essential points. The twenty-fourth chapter I have devoted to a very detailed and strictly scientific discussion of that section which Agassiz himself considers the most important (the groups or categories of systematic zoology and botany), and have shown that this part of his work is purely chimerical, without any trace of real foundation. Agassiz takes good care not to venture anywhere to touch upon my refutation, because, forsooth, he is not in a position to produce anything substantial against it. He fights not with arguments, but with phrases. However, such opposition will not delay the complete victory of the Theory of Development, but only accelerate it.

CHAPTER VI.

THEORY OF DEVELOPMENT ACCORDING TO LYELL
AND DARWIN.

Charles Lyell's Principles of Geology.—His Natural History of the Earth's Development.—Origin of the Greatest Effects through the Multiplication of the Smallest Causes.—Unlimited Extent of Geological Periods.—Lyell's Refutation of Cuvier's History of Creation.—The Establishment of the Uninterrupted Connection of Historical Development by Lyell and Darwin.—Biographical Notice of Charles Darwin.—His Scientific Works.—His Theory of Coral Reefs.—Development of the Theory of Selection.—A Letter of Darwin's.—The Contemporaneous Appearance of Darwin's and Alfred Wallace's Theory of Selection.—Darwin's Study of Domestic Animals and Cultivated Plants.—Andreas Wagner's notions as to the Special Creation of Cultivated Organisms for the good of Man.—The Tree of Knowledge in Paradise.—Comparison between Wild and Cultivated Organisms.—Darwin's Study of Domestic Pigeons.—Importance of Pigeon Breeding.—Common Descent of all Races of Pigeons.

DURING the thirty years, from 1830 until 1859, when Darwin's work appeared, the ideas of creation introduced by Cuvier remained predominant in the sciences of organic nature. People rested satisfied with the unscientific assumption, that in the course of the earth's history, a series of inexplicable revolutions had periodically annihilated the whole world of animals and plants, and that at the end of each revolution, and the beginning of a new period, a new,

enlarged, and improved edition of the organic population had appeared. Although the number of these editions of creation was altogether problematical, and in truth could not be fixed at all, and although the numerous advances which, during this time, were made in all the departments of zoology and botany demonstrated more and more that Cuvier's hypothesis was unfounded and untenable, and that Lamarck's natural theory of development was nearer the truth, yet the former maintained its authority almost universally among biologists. This must, above all, be ascribed to the veneration which Cuvier had acquired, and strikingly illustrates how injurious to the progress of humanity a faith in any definite authority may become. Authority, as Goethe once admirably said, perpetuates the individual, which as an individual should pass away, rejects and allows to pass that which should be held fast, and is the main obstacle to the advance of humanity.

It is only by having regard to the great weight of Cuvier's authority, and to the mighty potency of human indolence, which is with difficulty induced to depart from the broad and comfortable way of everyday conceptions, and to enter upon new paths not yet made easy, that we can comprehend how it is that Lamarck's Theory of Descent did not gain its due recognition until 1859, after Darwin had given it a new foundation. The soil had long been prepared for it by the works of Charles Lyell, another English naturalist, whose views are of great importance for the natural history of creation, and must accordingly here be briefly explained.

In 1830 Charles Lyell published, under the title of "Principles of Geology," a work in which he thoroughly reformed the science of Geology and the history of the earth's

development, and effected this reform in a manner similar to that in which, thirty years later, Darwin in his work reformed the science of Biology. Lyell's great treatise, which radically destroyed Cuvier's hypothesis of creation, appeared in the same year in which Cuvier celebrated his triumph over the nature-philosophy, and established his supremacy in the domain of morphology for the following thirty years. Whilst Cuvier, by his artificial hypothesis of creation and his theory of catastrophes connected with it, directly obstructed the path of the theory of natural development, and cut off all chance of a natural explanation, Lyell once more opened a free road, and brought forward convincing geological evidence to show that Cuvier's dualistic conceptions were as unfounded as they were superfluous. He demonstrated that those changes of the earth's surface, which are still taking place before our eyes, are perfectly sufficient to explain everything we know of the development of the earth's crust in general, and that it is superfluous and useless to seek for mysterious causes in inexplicable revolutions. He showed that we need only have recourse to the hypothesis of exceedingly long periods of time in order to explain the formation of the crust of the earth in the simplest and most natural manner by means of the very same causes which are still active. Many geologists had previously imagined that the highest chains of mountains which rise on the surface of the earth could owe their origin only to enormous revolutions transforming a great part of the earth's surface, especially to colossal volcanic eruptions. Such chains of mountains as those of the Alps or the Cordilleras were believed to have arisen direct from the fiery fluid of the interior of the earth, through an enormous chasm in the

broken crust. Lyell, on the other hand, showed that we can explain the formation of such enormous chains of mountains quite naturally by the same slow and imperceptible risings and depressions of the earth's surface which are still continually taking place, and the causes of which are by no means miraculous. Although these depressions and risings may perhaps amount only to a few inches, or at most a few feet, in the course of a century; still, in the course of some millions of years they are perfectly sufficient to raise up the highest chains of mountains, without the aid of mysterious and incomprehensible revolutions. In like manner, the meteorological action of the atmosphere, the influence of rain and snow, and, lastly, the breakers on the coasts, which by themselves seem to produce an insignificant effect, must cause the greatest changes if we only allow sufficiently long periods for their action. The multiplication of the smallest causes produces the greatest effects. Drops of water produce a cavity in a rock.

I shall afterwards be obliged again to recur to the immeasurable length of geological periods which are necessary for this purpose, for, as we shall see, Darwin's theory, as well as that of Lyell, renders the assumption of immense periods absolutely necessary. If the earth and its organisms have actually developed in a natural way, this slow and gradual development must certainly have taken a length of time which surpasses our powers of comprehension. But as many men see in this very circumstance one of the principal difficulties in the way of those theories of development, I beg leave here to remark that we have not a single rational ground for conceiving the time requisite to be limited in any way. Not only many ordinary persons, but even eminent

naturalists, make it their chief objection to these theories, that they arbitrarily claim too great a length of time: yet the ground of objection is scarcely intelligible. For it is absolutely impossible to see what can, in any way, limit us in assuming long periods of time. We have long known, even from the structure of the stratified crust of the earth alone, that its origin and the formation of neptunic rocks from water must have taken, at least, several millions of years. From a strictly philosophical point of view, it makes no difference whether we hypothetically assume for this process ten millions or ten thousand billions of years. Before us and behind us lies eternity. If the assumption of such enormous periods is opposed to the feelings of many, I regard this simply as the consequence of false notions which are impressed upon us from our earliest youth concerning the short history of the earth, which is said to embrace only a few thousands of years. Albert Lange, in his "History of Materialism,"¹² has convincingly shown that from a strictly philosophical point of view it is far less objectionable in a scientific hypothesis to assume periods which are too long than periods which are too short. Every process of development is the more intelligible the longer it is assumed to last. A short and limited period is the most improbable.

I have no space here to enter minutely into Lyell's great work, and will therefore mention only its most important result, which is, that he completely refuted Cuvier's history of creation with its mythical revolutions, and established in its place the constant and slow transformation of the earth's crust by the continued action of forces, which are still working on the earth's surface, viz. the movement of water and

the volcanic fluid of the interior of earth. Lyell thus demonstrated a continuous and uninterrupted connection of the whole history of the earth, and he proved it so irrefutably, and established so convincingly the supremacy of the "existing causes," that is, of the causes which are still active in the transformation of the earth's crust, that Geology in a short time completely renounced Cuvier's hypothesis.

Now, it is remarkable that Palæontology, the science of petrifications, so far as it was pursued by botanists and zoologists, remained apparently unaffected by this great progress in geology. Biology still continued to assume repeated new creations of the whole animal and vegetable kingdoms, at the beginning of every new period of the earth's history, although this hypothesis of individual creations, shoved into the world one after the other, without the assumption of Cuvier's cataclysms, became pure nonsense, and lost its foundation. It is evidently perfectly absurd to assume a distinct new creation of the whole world of animals and plants at definite epochs, without the crust of the earth itself experiencing any considerable general revolution. And although this conception is most closely connected with Cuvier's theory of catastrophes, still it prevailed when the latter had been completely destroyed and abandoned.

It was reserved for the great English naturalist, Charles Darwin, to remove this contradiction, and to show that the organic beings of the earth have a history as continuous and connected as the inorganic crust of the earth; that animals and plants have arisen from one another by as gradual a transmutation as that by which the varying forms of the earth's crust, the forms of the continents, and of the seas surrounding and separating them, have arisen out of earlier

and quite different forms. In this respect we may truly say that in the domain of Zoology and Botany Darwin made the same progress as Lyell, his great countryman, in the domain of Geology. Both proved the *uninterrupted connection of the historical development*, and demonstrated a gradual transmutation of the different conditions succeeding one another.

The special merit of Darwin, as I have already remarked in a preceding chapter, is twofold. In the first place, he has treated the Theory of Descent, put forth by Lamarck and Goethe, in a much more comprehensive manner, as a whole, and carried it out in a much more connected manner, than had been done by any one of his predecessors. Secondly, he has established the causal foundation of this Theory of Descent by the Theory of Selection, which is peculiarly his own; that is, he has demonstrated the acting *causes of the changes* which the Theory of Descent simply stated, as *facts*. The Theory of Descent, introduced into Biology in 1809, by Lamarck, asserts that all the different species of animals and plants are descended from a single or some few most simple prototypes, produced by spontaneous generation. The Theory of Selection, established in 1859 by Darwin, shows us *why* this must be so; it points out the acting causes in a manner with which Kant would have been delighted, and indeed, in the domain of organic nature, Darwin has become the Newton whose advent Kant thought himself entitled prophetically to deny.

Now, before we approach Darwin's theory, it will perhaps be of interest to notice a few details as to the personal character of this great naturalist, as to his life, and the way in which he was led to form his doctrine. Charles

Robert Darwin was born at Shrewsbury, on the Severn, on the 12th of February, 1809; therefore, at present he is sixty-three years old. In his seventeenth year (1825) he entered the University of Edinburgh, and two years later Christ's College, Cambridge. When scarcely twenty-two years old, in 1831, he was invited to take part in a scientific expedition which was sent out by England, in order to survey accurately the southernmost point of South America, and to examine several parts of the South Seas. This expedition, like many other voyages of inquiry fitted out in a praiseworthy manner by England, had scientific objects, and at the same time was intended to solve practical problems relating to navigation. The vessel, commanded by Captain Fitzroy, appropriately bore the symbolic name of the *Beagle*. The voyage of the *Beagle*, which lasted five years, was of the highest importance to the full development of Darwin's genius; for in the very first year, when he set his foot on the soil of South America, the outline of the doctrine of descent dawned upon him. Darwin himself has described this voyage in a work which is written in a very attractive style, and the perusal of which I strongly recommend to the reader. This book of travel, which lies far above the usual average in interest, not only shows in a very charming manner Darwin's amiable character, but we can in many ways recognize the various steps by which he arrived at his conceptions. The result of the voyage was, first, a large scientific work, the zoological and geological portion of which belong in a great measure to Darwin; and secondly, a celebrated work by him alone on Coral Reefs, which in itself would have sufficed to secure to him a lasting reputa-

tion. It is well known that the islands in the South Seas consist for the most part of coral reefs, and are surrounded by them. Formerly no satisfactory explanation could be given of their different and remarkable forms, and of their relation to those islands which are not formed of corals. It was reserved for Darwin to solve this difficult problem, for together with the constructive action of the coral zoophytes, he assumed geological risings and depressions of the bottom of the sea to account for the origin of the different forms of reefs. Darwin's Theory of the Origin of Coral Reefs, like his later one as to the Origin of Organic Species, is a theory which fully explains the phenomenon, and for this purpose assumes only the simplest natural causes, without hypothetically supporting it with any unknown processes. Among the remaining works of Darwin, I must not pass over his excellent monograph on Cirrhipedia, a curious class of marine animals, which in their outward appearance resemble mussels, and were actually considered by Cuvier as Molluscs possessing two shells, while in truth they belonged to the Crustacea (crabs).

The extraordinary hardships to which Darwin had been exposed during his voyage in the *Beagle* had injured his health to such a degree, that after his return home he was obliged to withdraw from the restless turmoil of London life, and since then has lived in quiet retirement on his estate at Down, near Bromley, in Kent. This seclusion from the restless activity of the great city certainly exercised a beneficial influence upon Darwin, and it is probable that we owe to it, at least partially, the formation of the Theory of Selection. Undisturbed by the various engagements which in London would have wasted his strength, he was enabled to concen-

trate his attention upon the great problem to which his mind had been turned during his voyage in the *Beagle*. In order to show what kind of observations during the voyage principally gave rise to the fundamental idea of the Theory of Selection, and in what manner he afterwards worked it out, I shall insert here a passage from a letter which he addressed to me on the 8th of October, 1864.

Letter from Charles Darwin to Haeckel, 8th October, 1864.

“In South America three classes of facts were brought strongly before my mind. *Firstly*, the manner in which closely allied species replace species in going southward. *Secondly*, the close affinity of the species inhabiting the islands near South America to those proper to the continent. This struck me profoundly, especially the difference of the species in the adjoining islets in the Galapagos Archipelago. *Thirdly*, the relation of the living Edentata and Rodentia to the extinct species. I shall never forget my astonishment when I dug out a gigantic piece of armour like that of the living armadillo.

“Reflecting on these facts, and collecting analogous ones, it seemed to me probable that allied species were descended from a common parent. But for some years I could not conceive how each form became so excellently adapted to its habits of life. I then began systematically to study domestic productions, and after a time saw clearly that man’s selective power was the most important agent. I was prepared, from having studied the habits of animals, to appreciate the struggle for existence, and my work in geology gave me some idea of the lapse of past time. Therefore, when I happened to read “Malthus on Population,” the idea

of natural selection flashed on me. Of all the minor points, the last which I appreciated was the importance and cause of the principle of divergence."

During the leisure and retirement in which Darwin lived after his return, he occupied himself, as we see from this letter, first and specially with the study of organisms in their cultivated state; that is, domestic animals and garden plants. This was undoubtedly the most likely way to arrive at the Theory of Selection. In this, as in all his labours, Darwin proceeded with extreme care and accuracy. With wonderful caution and self-denial, he published nothing on this subject during a period of twenty-one years, from 1837 to 1858, not even a preliminary sketch of his theory, which he had written as early as 1844. He was always anxious to collect still more certain experimental proofs, in order to be able to establish his theory in a complete form, and on the broadest possible foundation of experience. While he was thus aiming at the greatest possible perfection, which might perhaps have led him never to publish his theory at all, he was fortunately disturbed by a countryman of his, who, independently of Darwin, had discovered the Theory of Selection, and in 1858 sent its outlines to Darwin himself, with the request to hand them to Lyell for publication in some English journal. This was Alfred Wallace, one of the boldest and most distinguished scientific travellers of modern times. For many years Wallace had wandered alone in the wilds of the Sunda Islands, in the dense primitive forests of the Indian Archipelago; and during this close and comprehensive study of one of the richest and most interesting parts of the earth, with its great variety of animals and

plants, he had arrived at exactly the same general views regarding the origin of organic species as Darwin. Lyell and Hooker, both of whom had long known Darwin's work, now induced him to publish a short extract from his manuscripts simultaneously with the manuscript sent him by Wallace. They appeared in the *Journal of the Linnean Society*, August, 1858.

Darwin's great work "On the Origin of Species," in which the Theory of Selection is carried out in detail, appeared in November, 1859. Darwin himself, however, characterizes this book (of which a fifth edition appeared in 1869, and the German translation by Bronn as early as 1860)¹ as only a preliminary extract from a larger and more detailed work, which is to contain a mass of facts in favour of his theory, and comprehensive and experimental proofs. The first part of the larger work promised by Darwin appeared in 1868, under the title, "The Variations of Animals and Plants in the State of Domestication," and has been translated into German by Victor Carus.¹⁴ It contains a rich abundance of the most valuable evidence as to the extraordinary changes of organic forms which man can produce by cultivation and artificial selection. However much we are indebted to Darwin for this abundance of convincing facts, still we do not by any means share the opinion of those naturalists who hold that the Theory of Selection requires for its actual proof these further details. It is our opinion that Darwin's first work, which appeared in 1859, already contains sufficient proof. The unassailable strength of his theory does not lie in the immense amount of individual facts that may be adduced as proofs, but in the harmonious connection of all the great and general phe-

nomena of organic nature, which agree in bearing testimony to the truth of the Theory of Selection.

Darwin, at first, intentionally did not notice the important conclusion from his Theory of Descent, namely, the descent of the human race from other mammals. It was not till this highly important conclusion had been definitely established by other naturalists as the necessary sequel of the doctrine of descent, that Darwin himself expressly endorsed it, and thereby completed his system. This was done in the highly interesting work, "The Descent of Man, and Sexual Selection," which appeared as late as 1871, and has likewise been translated into German by Victor Carus.⁴⁸

The careful study which Darwin devoted to *domestic animals* and *cultivated plants* was of the greatest importance in establishing the Theory of Selection. The infinitely varied changes of form which man has produced in these domesticated organisms by artificial selection are of the very highest importance for a right understanding of animal and vegetable forms; and yet this study has, down to the most recent times, been most grossly neglected by zoologists and botanists. Without entering upon the discussion of the significance to be attached to the idea of species itself, they have filled not only bulky volumes, but whole libraries, with descriptions of individual species, and with most childish controversies as to whether these species are good, or tolerably good, and bad, or tolerably bad. If naturalists instead of spending their time on these useless fancies had duly studied cultivated organisms, and had examined the transmutation of the living forms, instead of the individual dead ones, they would not have been led captive so long by the fetters of Cuvier's dogma. But as cultivated organisms

are so extremely inconvenient to the dogmatic conception of the permanence of species, naturalists to a great extent intentionally did not concern themselves about them, and even celebrated naturalists have often expressed the opinion that cultivated organisms, domesticated animals and garden plants, are artificial productions of man, and that their formation and transformation could not decide anything about the nature of species and about the origin of the forms of species that live in a natural state.

This perverse view went so far that, for example, Andreas Wagner, a zoologist of Munich, quite seriously made the following ridiculous assertion:—"Animals and plants in their wild state have been called into being by the Creator as distinctly different and unchangeable species; but in the case of domestic animals and cultivated plants this was not necessary, because he formed them from the beginning for the use of man. The Creator formed man out of a clod of earth, breathed the living breath into his nostrils, and then created for him the different useful domestic animals and garden plants, among which he thought well to save himself the trouble of distinguishing species." Unfortunately, Andreas Wagner does not tell us whether the *Tree of Knowledge* in Paradise was a "good" wild species, or, as a cultivated plant, "no species" at all. As the Tree of Knowledge was placed by the Creator in the centre of Paradise, we might be inclined to believe that it was a highly favoured cultivated plant, and therefore no species at all. But since, on the other hand, the fruit of the Tree of Knowledge was forbidden to man, and since many men, as Wagner himself clearly shows, have never eaten of the fruit, it was evidently not created for the use of man, and therefore in

all probability was a *real species*! What a pity Wagner has not given us any information about this important and difficult problem!

Now, however ridiculous this view may appear to us, it is only the logical sequence of a false view (which is widely spread) of the special nature of cultivated organisms, and one may occasionally hear similar objections from naturalists of great reputation. I must most decidedly, and at once, condemn this utterly false conception. It is the same perverseness which is committed by physicians who maintain that diseases are artificial productions, and not natural phenomena. It has been a work of hard labour to combat this prejudice, and it is only in recent times that men have generally adopted the view that diseases are nothing but natural changes of the organisms, or really natural phenomena of life, which are produced by changed and abnormal conditions of existence. Disease, therefore, is not a life beyond Nature's realm (*vita præter naturam*), as the early physicians used to say, but a natural life under conditions which produce illness and threaten the body with danger. Just in the same manner, cultivated organic forms are not artificial works of man, but natural productions which have arisen under the influence of peculiar conditions of life. Man by his culture can never directly produce a new organic form, but he can breed organisms under new conditions of life, which are such as to influence and transform them. All domestic animals and all garden plants are originally descended from wild species, which have been transformed by the peculiar conditions of culture.

A thorough comparison of cultivated forms (races and varieties) with organisms not altered by cultivation (species

and varieties), is of the utmost importance to the theory of selection. What is most surprising in such a comparison is the remarkably short time in which man can produce a new form, and the high degree in which this form, produced by man, can deviate from the original form. While wild animals and plants, one year after another, appear to the zoologist and botanist approximately in the same form, so as to have given rise to the false doctrine of the constancy of species, domestic animals and garden plants, on the other hand, display the greatest changes within a few years. The perfection which gardeners and farmers have attained in the art of selection now enables them, in the space of a few years, arbitrarily to create entirely new animal and vegetable forms. For this purpose it is only necessary to keep and propagate the organism under the influence of special conditions—which are capable of producing new formations—and even at the end of a few generations new species may be obtained, which differ from the original form in a much higher degree than so-called good species in a wild state differ from one another. This fact is extremely important, and we cannot lay sufficient stress upon it. The assertion is not true that cultivated forms descended from one and the same primary form do not differ from one another as much as wild animal and vegetable species differ among themselves. If we only make comparisons, without prejudice, we can very easily perceive that a number of races or varieties which have been derived from a single cultivated form, within a short series of years, differ from one another in a higher degree than so-called good species (*bonæ species*), or even different genera of one family, in the wild state.

In order to establish this extremely important fact as firmly as possible by experiments, Darwin decided to make a special study of the whole extent of variation in form in a single group of domesticated animals, and for this purpose he chose the *domestic pigeons*, which are in many respects especially suited for such a study. For a long time he kept on his estate all possible races and varieties of pigeons which he was able to procure, and he was helped in this by rich contributions from all parts of the world. He also joined two London pigeon clubs, the members of which passionately, and with truly artistic skill, carry on the breeding of the different forms of pigeons. Lastly, he formed connections with some of the most celebrated pigeon-fanciers; so that he could command the richest experimental material.

The art of, and fancy for, pigeon breeding is very ancient. Even more than 3,000 years before Christ, it was carried on by the Egyptians. The Romans, under the emperors, laid out enormous sums upon the breeding of pigeons, and kept accurate pedigrees of their descent, just as the Arabs keep genealogical pedigrees of their horses, and the Mecklenburg aristocracy of their own ancestors. In Asia, too, among the wealthy princes, pigeon breeding was a very ancient fancy; in 1600, the court of Akber Khan possessed more than 20,000 pigeons. Thus in the course of several centuries, and in consequence of the various methods of breeding practised in the different parts of the world, there has arisen out of one single originally tamed form, an immense number of different races and varieties, which in their most divergent forms are extremely different from one another, and are often curiously characterized.

One of the most striking races of pigeons is the well-

known fan-tailed pigeon, which spreads its tail like the peacock, and carries a number of (from thirty to forty) feathers placed in the form of radii, while other pigeons possess much fewer tail feathers—generally twelve. We may here mention that the number of feathers on the tails of birds is considered by naturalists of great value as a systematic distinction, so that whole orders can thereby be distinguished. For example, singing birds, almost without exception, possess twelve tail feathers; chirping birds (Strisores) ten, etc. Several races of pigeons, moreover, are characterized by a tuft of neck feathers, which form a kind of periwig; others by grotesque transformation of their beaks and feet, by peculiar and often very remarkable decorations, as, for example, skinny lappets, which develop on the head; by a large crop, which is formed by the gullet being strongly inclined forward, etc. Remarkable, also, are the strange habits which many pigeons have acquired; for example, the turtle pigeons and the trumpeters with their musical accomplishments, the carriers with their topographical instinct. The tumblers have the strange habit of ascending into the air in great numbers, then turning over and falling down through the air as if dead. The ways and habits of these endless races of pigeons—the form, size, and colour of the individual parts of their bodies, and their proportions, differ in a most astonishing degree from one another; in a much higher degree than is the case with the so-called good species, or even with the perfectly distinct genera, of wild pigeons. And what is of the greatest importance, is the fact that these differences are not confined to the external form, but extend even to the most important internal parts; there even occur great modifications of the skeleton and of the muscular

tissues. For example, we find great differences in the number of vertebræ and ribs, in the size and shape of the gaps in the breast-bones, in the size and shape of the merry-thought, in the lower jaw, in the facial bones, etc. In short, the bony skeleton, which morphologists consider a very permanent part of the body, and which never varies to such an extent as the external parts—shows such great changes, that many races of pigeons might be described as special genera, and this would doubtless be done if all these different forms had been found in a wild and natural state.

How far the differences of the races of pigeons have been carried is best shown by the fact that all pigeon breeders are unanimously of opinion that each peculiar or specially marked race of pigeons must be derived from a corresponding wild original species. It is true every one assumes a different number of original species. Yet Darwin has most convincingly and acutely proved that all these pigeons, without exception, must be derived from a single wild primary species—from the blue rock-pigeon (*Columba livia*.) In like manner, it can be proved of most of the domestic animals and cultivated plants, that all the different races are descendants of a single original wild species which has been brought by man into a cultivated condition.

An example similar to that of the domestic pigeons is furnished among mammals by our tame *rabbit*. All zoologists, without exception, have long considered it proved that all its races and varieties are descended from the common wild rabbit, that is, from a single primary species. And yet the extreme forms of these races differ to such a degree from one another, that every zoologist, if he met with them in a wild state, would unhesitatingly designate them not only as

an. entirely distinct "good species," but even as species of entirely different genera of the Leporid family. Not only does the colour, length of hair, and other qualities of the fur of the different tame races of rabbits vary exceedingly, and form extremely broad contrasts, but, what is still more important, the typical form of the skeleton and its individual parts do so also, especially the form of the skull and the jaw (which is of such importance in systematic arrangement); further, the relative proportion of the length of the ears, legs, etc. In all these respects the races of tame rabbits avowedly differ from one another far more than all the different forms of wild rabbits and hares which are scattered over all the earth, and are the recognized "good species" of the genus *Lepus*. And yet, in the face of these clear facts, the opponents of the theory of development maintain that the wild species are not descended from a common prototype, although they at once admit it in the case of the tame races. With opponents who so intentionally close their eyes against the clear light of truth, no further dispute can be carried on.

While in this manner it appears certain that the domestic races of pigeons, of tame rabbits, of horses, etc., notwithstanding the remarkable difference of their varieties, are descended in each case from but one wild, so-called "species"; yet, on the other hand, it is certainly probable that the great variety of races of some of the domestic animals, especially dogs, pigs, and oxen, must be ascribed to the existence of several wild prototypes, which have become mixed. It is, however, to be observed that the number of these originally wild primary species is always much smaller than that of the cultivated forms proceeding from

their mingling and selection, and naturally they were originally derived from a single primary ancestor, common to the whole genus. In no case is each separate cultivated race descended from a distinct wild species.

In opposition to this, almost all farmers and gardeners maintain, with the greatest confidence, that each separate race bred by them must be descended from a separate wild primary species, because they clearly perceive the differences of the races, and attach very high importance to the inheritance of their qualities; but they do not take into consideration the fact that these qualities have arisen only by the slow accumulation of small and scarcely observable changes. In this respect it is extremely instructive to compare cultivated races with wild species.

Many naturalists, and especially the opponents of the Theory of Development, have taken the greatest trouble to discover some morphological or physiological mark, some characteristic property, whereby the artificially bred and cultivated races may be clearly and thoroughly distinguished from wild species which have arisen naturally. All these attempts have completely failed, and have led only with increasing certainty to the result, that such a distinction is altogether impossible. I have minutely discussed this fact, and illustrated it by examples in my criticism of the idea of species. (Gen. Morph. ii. 323-364.)

I may here briefly touch on yet another side of this question, because not only the opponents, but even a few of the most distinguished followers of Darwin—for example, Huxley—have regarded the phenomena of *bastard-breeding*, or *hybridism*, as one of the weakest points of Darwinism. Between cultivated races and wild species, they say, there

exists this difference, that the former are capable of producing fruitful bastards, but that the latter are not. Two different cultivated races, or wild *varieties of one species*, are said in all cases to possess the power of producing bastards which can fruitfully mix with one another, or with one of their parent forms, and thus propagate themselves; on the other hand, *two really different species*, two cultivated or wild *species* of one genus, are said *never* to be able to produce from one another bastards which can be fruitfully crossed with one another, or with one of their parent species.

As regards the first of these assertions, it is simply refuted by the fact that there are organisms which do not mix at all with their own ancestors, and therefore can produce no fruitful descendants. Thus, for example, our cultivated guinea-pig does not bear with its wild Brazilian ancestor; and again, the domestic cat of Paraguay, which is descended from our European domestic cat, no longer bears with the latter. Between different races of our domestic dogs, for example, between the large Newfoundland dogs and the dwarfed lap-dogs, breeding is impossible, even for simple mechanical reasons. A particularly interesting instance is afforded by the Porto-Santo rabbit (*Lepus Huxleyi*). In the year 1419, a few rabbits, born on board ship of a tame Spanish rabbit, were put on the island of Porto Santo, near Madeira. These little animals, there being no beasts of prey, in a short time increased so enormously that they became a pest to the country, and even compelled a colony to remove from the island. They still inhabit the island in great numbers; but in the course of four hundred and fifty years they have developed into a quite

peculiar variety—or if you will have it, into a “good species”—which is distinguished by a peculiar colour, a rat-like shape, small size, nocturnal life, and extraordinary wildness. The most important fact, however, is that this new species, which I call *Lepus Huxleyi*, no longer pairs with its European parent rabbit, and no longer produces bastards with it.

On the other hand, we now know of numerous examples of fruitful genuine bastards; that is, of mixings that have proceeded from the crossing of two entirely different species, and yet propagate themselves with one another as well as with one of their parent species. A number of such bastard species (species Hybridæ) have long been known to botanists; for example, among the genera of the thistle (*Cirsium*), the laburnum (*Cytisus*), the bramble (*Rubus*), etc. Among animals also they are by no means rare, perhaps even very frequent. We know of fruitful bastards which have arisen from the crossing of two different species of a genus, as among several genera of butterflies (*Zygæna*, *Saturnia*), the family of carps, finches, poultry, dogs, cats, etc. One of the most interesting is the hare-rabbit (*Lepus Darwinii*), the bastard of our indigenous hare and rabbit, many generations of which have been bred in France, since 1850, for gastronomic purposes. I myself possess such hybrids, the products of pure in-breeding, that is, both parents of which are themselves hybrids by a hare-father and a rabbit-mother. I possess them through the kindness of Professor Conrad, who has repeatedly made these experiments in breeding on his estate. The half-blood hybrid thus bred, which I name in honour of Darwin, appears to propagate itself through many generations by pure in-breeding, just as well as any

genuine species. Although on the whole it is more like its mother (rabbit), still in the formation of the ears and of the hind-legs, it possesses distinct qualities of its father (hare). Its flesh has an excellent taste, rather resembling that of a hare, though the colour is more like that of a rabbit. But the hare (*Lepus timidus*) and the rabbit (*Lepus cuniculus*) are two species of the genus *Lepus*, so different that no systematic zoologist will recognize them as varieties of one species. Both species, moreover, live in such different ways, and in their wild state entertain so great an aversion towards one another, that they do not pair so long as they are left free. If, however, the newly-born young ones of both species are brought up together, this aversion is not developed; they pair with one another and produce the *Lepus Darwinii*.

Another remarkable instance of the crossing of different species (where the two species belong even to different genera!) is furnished by the fruitful hybrids of sheep and goats which have for a long time been bred in Chili for industrial purposes. On what unessential circumstances in the sexual mingling the fertility of the different species depend, is shown by the fact that he-goats and sheep in their mingling produce fruitful hybrids, while the ram and she-goat pair very rarely, and then without result. The phenomena of hybridism to which undue importance has been erroneously attributed are thus utterly unmeaning, so far as the idea of species is concerned. The breeding of hybrids does not enable us, any more than other phenomena, thoroughly to distinguish cultivated races from wild species; and this circumstance is of the greatest importance in the Theory of Selection.

CHAPTER VII.

THE THEORY OF SELECTION (DARWINISM).

Darwinism (Theory of Selection) and Lamarckism (Theory of Descent).—

The Process of Artificial Breeding.—Selection of the Different Individuals for After-breeding.—The Active Causes of Transmutation.—Change connected with Food, and Transmission by Inheritance connected with Propagation.—Mechanical Nature of these Two Physiological Functions.—The Process of Natural Breeding: Selection in the Struggle for Existence.—Malthus' Theory of Population.—The Proportion between the Numbers of Potential and Actual Individuals of every Species of Organisms.—General Struggle for Existence, or Competition to attain the Necessaries of Life.—Transforming Force of the Struggle for Existence.—Comparison of Natural and Artificial Breeding.—Selection in the Life of Man.—Military and Medical Selection.

It is, properly speaking, not quite correctly that the Theory of Development, with which we are occupied in these pages, is usually called Darwinism. For, as we have seen from the historical sketch in the previous chapters, the most important foundation of the Theory of Development—that is, the Doctrine of Filiation, or Descent—had already been distinctly enunciated at the beginning of our century, and had been definitely introduced into science by Lamarck. The portion of the Theory of Development which maintains the common descent of all species of animals and plants from the simplest common original forms might, therefore, in

honour of its eminent founder, and with full justice, be called *Lamarckism*, if the merit of having carried out such a principle is to be linked to the name of a single distinguished naturalist. On the other hand, the Theory of Selection, or breeding, might be justly called *Darwinism*, being that portion of the Theory of Development which shows us in what way and *why* the different species of organisms have developed from those simplest primary forms. (Gen. Morph. ii. 166).

It is true we find the first trace of an idea of natural selection even forty years before the appearance of Darwin's work. For in the year 1818 there was published a paper "On a woman of the white race whose skin partly resembled that of a negro," which had been read before the Royal Society as early as 1813. Its author, Dr. W. C. Wells, states that negroes and mulattoes are distinguished from the white race by their immunity from certain tropical diseases. On this occasion he remarks that all animals have a tendency to change up to a certain degree, and that farmers, by availing themselves of this tendency, and also by selection, improve their domestic animals; and then he adds, that what is done in this latter case "by art, seems to be done with equal efficiency, though more slowly, by nature, in the formation of varieties of mankind fitted for the country which they inhabit. Of the accidental varieties of man which would occur among the first few and scattered inhabitants of the middle regions of Africa, some one would be better fitted than the others to bear the diseases of the country. This race would consequently multiply, while the others would decrease; not only from their inability to sustain the attacks of disease, but from their incapacity of contending with

their more vigorous neighbours. The colour of this vigorous race I take for granted, from what has been already said, would be dark. But the same disposition to form varieties still existing, a darker and a darker race would in the course of time occur; and as the darkest would be the best fitted for the climate, this would at length become the most prevalent, if not the only race, in the particular country in which it had originated." He then extends these same views to the white inhabitants of colder climates. Although Wells clearly expresses and recognizes the principle of natural selection, yet it is applied by him only to the very limited problem of the origin of human races, and not at all to that of the origin of animal and vegetable species. Darwin's great merit in having independently developed the Theory of Selection, and having brought it to complete and well merited recognition, is as little affected by the earlier and long forgotten remark of Wells, as by some other fragmentary observations about natural selection made by Patrick Mathew, and hidden in his book on "Timber for Shipbuilding, and the Cultivation of Trees," which appeared in 1831. The celebrated traveller, Alfred Wallace, who developed the Theory of Selection independently of Darwin, and had published it in 1858, simultaneously with Darwin's first contribution, likewise stands far behind his greater and elder countryman in regard to profound conception, as well as to extended application of the theory. In fact Darwin, by his extremely comprehensive and ingenious development of the whole doctrine, has acquired a fair claim to see the theory connected with his own name.

This Theory of Selection, Darwinism in its proper sense, to the consideration of which we now turn our attention,

rests essentially (as has already been intimated in the last chapter) upon the comparison of those means which man employs in the breeding of domestic animals and the cultivation of garden plants, with those processes which in free nature, outside the cultivated state, lead to the coming into existence of new species and new genera. We must therefore, in order to understand the latter processes, first turn to the artificial breeding by man, as was, in fact, done by Darwin himself. We must inquire into the results to which man attains by his artificial breeding, and what means are applied in order to obtain those results; and we must then ask ourselves, "Are there in nature similar forces and causes acting similarly to those resorted to by man?"

First, in regard to artificial breeding, we start from the fact last discussed above, viz. that its products in some cases differ from one another much more than the productions of natural breeding. It is a fact that races or varieties often differ from one another in a much greater degree and in much more important qualities than many so-called species, or "good species,"—nay, sometimes even more than so-called "good genera" in their natural state. Compare, for example, the different kinds of apples which the art of horticulture has derived from one and the same original apple-form, or compare the different races of horses which their breeders have derived from one and the same original form of horse, and it will be easily observed that the differences of the most different forms are extremely important, and much more important than the so-called "specific differences," which are referred to by zoologists and botanists when comparing wild forms for the purpose of distinguishing several so-called "good species."

Now, by what means does man produce this extraordinary difference or divergence of several forms which are proved to be descended from the same primary form? In order to answer this question, let us follow a gardener who desires to produce a new form of a plant, which is distinguished by the beautiful colour of its flowers. He will first of all make a selection from a great number of plants which are seedlings from one and the same parent. He will pick out those plants which exhibit most distinctly the colour of flower he desires. The colour of flowers is a very changeable thing. Plants, for example, which as a rule have a white flower, frequently show deviations into the blue or red. Now, supposing the gardener wishes to obtain the red colour in a plant usually producing white flowers, he will very carefully, from among the many different individuals which are the descendants of one and the same seed-plant, select those which most distinctly show a reddish tint, and sow them exclusively, in order to produce new individuals of the same kind. He would cast aside and no longer cultivate the other seedlings which show a white or less distinct red colour. He will propagate exclusively the individual plants whose blossoms show the red most markedly, and he will sow the seeds produced by these selected plants. From the seedlings of this second generation, he will again carefully select those in which the red, which is now visible in the majority of them, is most distinctly displayed. If such a selection is carried on during a series of six or ten generations, and if the flower which shows the deepest red is most carefully selected, the gardener in the sixth or tenth generation will obtain the desired plants with flowers of a pure red.

The farmer wishing to breed a special race of animals, for example, a kind of sheep distinguished by particularly fine wool, proceeds in the same manner. The only process applied in the improvement of wool consists in this, that the farmer with the greatest care and perseverance selects from a whole flock of sheep those individuals which have the finest wool. These only are used in breeding, and among the descendants of these selected sheep, those again are chosen which have the finest wool, etc. If this careful selection is carried on through a series of generations, the selected breeding-sheep are in the end distinguished by a wool which differs very strikingly from the wool of the original parent, and this is exactly the advantage which the breeder desired.

The differences of the individuals that come into consideration in this artificial selection are very slight. An ordinary unpractised man is unable to discover the exceedingly minute differences of individuals which a practised breeder perceives at the first glance. The business of a breeder is not easy; it requires an exceedingly sharp eye, great patience, and an extremely careful manner of treating the organisms to be bred. In each individual generation, the differences of individuals are perhaps not seen at all by the uninitiated; but by the accumulation of these minute differences during a series of generations, the deviation from the original form becomes in the end very great. It becomes so great that the artificially produced form may in the end differ far more from the original form than do two so-called "good species" in their natural state. The art of breeding has now made such progress, that man can often at discretion produce certain peculiarities in cultivated species

of animals and plants. To practised gardeners and farmers, you may give distinct commissions, and say, for example, I wish to have this species of plant with this or that colour, and with this or that shape. Where breeding has reached the perfection which it has attained in England, gardeners and farmers are frequently able to furnish to order the desired result within a definite period, that is, at the end of a number of generations. Sir John Sebright, one of the most experienced English pigeon-breeders, could assert that in three years he would produce any form of feather, but that he required six years to obtain any desired form of the head and beak. In the process of breeding the merino-sheep of Saxony, the animals are three times placed on a table beside one another, and most carefully compared and studied. Each time only the best sheep with the finest wool are selected, so that in the end, out of a great multitude, there remain only some few animals, but their wool is exquisitely fine, and only these last are used in breeding. We see, therefore, that the causes through which, in artificial breeding, great effects are produced, are unusually simple, and these great effects are obtained simply by accumulating the differences which in themselves are very insignificant, and become surprisingly increased by a continually repeated selection.

Before we pass on to a comparison of this artificial with natural breeding, let us see what natural qualities of the organisms are made use of by the artificial breeder or cultivator. We can trace all the different qualities which here come into play to physiological fundamental qualities of the organism, which are common to all animals and plants, and are most closely connected with the functions of

propagation and *nutrition*. These two fundamental qualities are *transmissivity*, or the capability of *transmitting by inheritance*, and *mutability*, or the capability of *adaptation*. The breeder starts from the fact that all the individuals of one and the same species are different, though in a very slight degree, a fact which is as true of organisms in a wild as in a cultivated state. If you look about you in a forest consisting of only a single species of tree, for example of beech, you will certainly not find in the whole forest two trees of this kind which are absolutely identical or perfectly equal in the form of their branches, the number of their branches and leaves, blossoms and fruits. Special differences occur everywhere, just as in the case of men. There are no two men who are absolutely identical, perfectly equal in size, in the formation of their faces, the number of their hairs, their temperament, character, etc. The very same is true of individuals of all the different species of animals and plants. It is true that in most organisms the differences are very trifling to the eye of the uninitiated. Everything here essentially depends on the exercise of the faculty of discovering these often very minute differences of form. The shepherd, for example, knows every individual of his flock, solely by accurately observing their features, while the uninitiated are incapable of distinguishing at all the different individuals of one and the same flock. This fact of the individual difference is the extremely important foundation on which the whole of man's power of breeding rests. If individual differences did not exist everywhere, man would not be able to produce a number of different varieties or races from one and the same original stock. We must, at the outset, hold fast the principle that the phenomenon is

quite universal; we must necessarily assume it even where, with the imperfect capabilities of our senses, we are unable to discover differences. Among the higher plants (the phanerogams, or flower-plants), where the individual stocks show such numerous differences in the number of branches or leaves, and in the formation of the stem and branches, we can almost always easily perceive these differences. But this is not the case in the lower plants, such as mosses, algæ, fungi, and in most animals, especially the lower ones. The distinction of all the individuals of one species is here, for the most part, extremely difficult or altogether impossible. But there is no reason for ascribing individual differences only to those organisms in which we can perceive them at once. We may, on the contrary, with full certainty assume such individuality as a universal quality of all organisms, and we can do this all the more surely since we are able to trace the mutability of individuals to the mechanical conditions of nutrition. We can show that by influencing nutrition we are able to produce striking individual differences where they would not exist if the conditions of nutrition had not been altered. The many complicated conditions of nutrition are never absolutely identical in two individuals of a species.

Now, just as we see that the mutability or capability of adaptation has a causal connection with the general relations of nutrition in animals and plants, so too we find the second fundamental phenomenon of life, with which we are here concerned, namely, the capability of *transmitting by inheritance*, to have a direct connection with the phenomenon of *propagation*. The second thing that a farmer or gardener does in artificial breeding, after he has selected, and has consequently availed himself of the mutability, is

to endeavour to hold fast and develop the modified forms by Inheritance. He starts from the universal fact that children resemble their parents, that "the apple does not fall far from the tree." This phenomenon of Inheritance has hitherto been scientifically examined only to a very small extent, which may partly arise from the fact that the phenomenon is of such everyday occurrence. Every one considers it quite natural that every species should produce its like; that a horse should not suddenly produce a goose, or a goose a frog. We are accustomed to look upon these everyday occurrences of Inheritance as self-evident. But this phenomenon is not so simply self-evident as it appears at first sight, and in the examination of Inheritance the fact is very frequently overlooked that the different descendants, derived from one and the same parents, are in reality *never* quite identical, and also never absolutely like the parents, but are always slightly different. We cannot formulate the principle of Inheritance, as "Like produces like," but we must limit the expression to "Similar things produce similar things." The gardener, as well as the farmer, avails himself of the fact of Inheritance in its widest form, and indeed with special regard to the fact that not only those qualities of organisms are transmitted by inheritance which they have inherited from *their* parents, but those also which they themselves have *acquired*. This is an important point upon which very much depends. An organism can transmit to its descendants not only those qualities of form, colour, and size which it has inherited from its parents, but it can also transmit changes of these qualities, which it has acquired during its own life through the influence of outward circumstances, such as climate, nourishment, training, etc.

These are the two fundamental qualities of animals and plants of which the breeder must avail himself in order to produce new forms. The theoretical principle of breeding is, indeed, extremely simple, but in detail the practical application of this simple principle is difficult and immensely complicated. A thoughtful breeder, acting according to a definite plan, must understand the art of correctly estimating, in every case, the general interaction between the two fundamental qualities of heirship and mutability.

Now, if we examine the real nature of those two important properties of life, we find that we can trace them, like all physiological functions, to physical and chemical causes, to the properties and the phenomena of motion of those substances of which the bodies of animals and plants consist. As we shall hereafter have to show in the more accurate consideration of these two functions, the transmission by *Inheritance*, if we express ourselves quite generally, is essentially dependent upon the material continuity and partial identity of the matter in the producing and produced organism, the parents and the child. In every act of breeding a certain quantity of protoplasm or albuminous matter is transferred from the parents to the child, and along with it there is transferred the individually *peculiar molecular motion*. These molecular phenomena of motion in the protoplasm, which call forth the phenomena of life, and are their active and true cause, differ more or less in all living individuals; they are of infinite variety.

Adaptation, or transmutation is, on the other hand, essentially the consequence of material influences, which the substance of the organism experiences from the material surrounding it,—in the widest sense of the word from the

conditions of life. The external influences of the latter are communicated to the individual parts of the body by the molecular processes of nutrition. In every act of Adaptation the individual molecular motion of the protoplasm, peculiar to each part, disturbs and modifies the whole individual, or part of it, by mechanical, physical, or chemical influences. The innate, inherited vital actions of the protoplasm—that is, the molecular phenomena of motion of the smallest albuminous particles—are therefore more or less modified by it. The phenomenon of Adaptation, or transmutation, depends therefore upon the material influence which the organism experiences from its surroundings, or its conditions of existence; while the transmission by Inheritance is due to the partial identity of the producing and produced organism. These are the real, simple, mechanical foundations of the artificial process of breeding.

Now Darwin asked himself, Does there exist a similar process of selection in nature, and are there forces in nature which take the place of man's activity in artificial selection? Is there a natural tendency among wild animals and plants which acts selectingly, in a similar manner to the artificial selection practised by the designing will of man? All here depended upon the discovery of such a relation, and Darwin succeeded in this so satisfactorily, that we consider his theory of selection completely sufficient to explain, mechanically, the origin of the wild species of animals and plants. That relation which in free nature influences the forms of animals and plants, by selecting and transforming them, is called by Darwin the "*Struggle for Existence*."

The "Struggle for Existence" has rapidly become a

watchword of the day. Yet this designation is, perhaps, in many respects not very happily chosen, and the phenomena might probably have been more accurately described as "*Competition for the Means of Subsistence*." For under the name of "Struggle for Life," many relations are comprehended which properly and strictly speaking do not belong to it. As we have seen from the letter inserted in the last chapter, Darwin arrived at the idea of the "Struggle for Existence" from the study of Malthus' book "*On the Conditions and the Consequences of the Increase of Population*." It was proved in that important work, that the number of human beings, on the average, increases in a geometrical progression, while the amount of articles of food increase only in an arithmetical progression. This disproportion gives rise to a number of inconveniences in the human community, which cause among men a continual competition to obtain the necessary means of life, which do not suffice for all.

Darwin's theory of the struggle for life is, to a certain extent, a general application of Malthus' theory of population to the whole of organic nature. It starts from the consideration that the number of *possible* organic individuals which might arise from the germs produced, is far greater than the number of *actual* individuals which, in fact, do simultaneously live on the earth's surface. The number of possible or *potential individuals* is given us by the number of the eggs and organic germs produced by organisms. The number of these germs, from each of which, under favourable circumstances, an individual might arise, is very much larger than the number of real or actual *individuals*—that is, of those that really arise from these

germs, come into life, and propagate themselves. By far the greater number of germs perish in the earliest stage of life, and it is only some favoured organisms which manage to develop, and actually survive the first period of early youth, and finally succeed in propagating themselves. This important fact is easily proved by a comparison of the number of eggs in a given species with the number of individuals which exist of this species. These numerical relations show the most striking contrast. There are, for example, species of fowls which lay great numbers of eggs, and yet are among the rarest of birds; and the bird which is said to be the commonest (the most widely spread) of all, the stormy petrel (*Procellaria glacialis*), lays only a single egg. The relation is the same in other animals. There are many very rare invertebrate animals, which lay immense quantities of eggs; and others again which produce only very few eggs, and yet are among the commonest of animals. Take, for example, the proportion which is observed among the human tape-worms. Each tape-worm produces within a short period millions of eggs, while man, in whom these tape-worms are lodged, forms a far smaller number of eggs, and yet fortunately there are fewer tape-worms than human beings. In like manner, among plants there are many splendid orchids, which produce thousands of seeds and yet are very rare, and some kinds of asters (*Compositæ*), which have but few seeds, are exceedingly common.

This important fact might be illustrated by an immense number of examples. It is evidently, therefore, not the number of actually existing germs which indicates the number of individuals which afterwards come into life and maintain themselves in life; but rather the case is this,

that the number of adult individuals is limited by other circumstances, especially by the relations in which the organism stands to its organic and inorganic surroundings. Every organism, from the commencement of its existence, struggles with a number of hostile influences: it struggles against animals which feed on it, and to which it is the natural food, against animals of prey and parasites; it struggles against inorganic influences of the most varied kinds, against temperature, weather, and other circumstances; but it also struggles (and this is much the most important!), above all, against organisms most like and akin to itself. Every individual, of every animal and vegetable species, is engaged in the fiercest competition with every other individual of the same species which lives in the same place with it. In the economy of nature the means of subsistence are nowhere scattered in abundance, but are very limited, and far from sufficient for the number of organisms which might develop from the germs produced. Therefore the young individuals of most species of animals and vegetables must have hard work in obtaining the means of subsistence; this necessarily causes a competition among them in order to obtain the indispensable supplies of life.

This great competition for the necessities of life goes on everywhere and at all times, among human beings and animals as well as among plants; in the case of the latter this circumstance, at first sight, is not so clearly apparent. If we examine a field which is richly sown with wheat, we can see that of the numerous young plants (perhaps some thousands) which shoot up on a limited space, only a very small proportion preserve themselves in life. A competition takes place for the space of ground which each plant

requires for fixing its root, a competition for sunlight and moisture. And in the same manner we find that, among all animal species, all the individuals of one and the same species compete with one another to obtain these indispensable means of life, or the conditions of existence in the wide sense of the word. They are equally indispensable to all, but really fall to the lot of only a few—"Many are called, but few are chosen." The fact of the great competition is quite universal. You need only to cast a glance at human society, where this competition exists everywhere, and in all the different branches of human activity. Here, too, a struggle is brought about by the free competition of the different labourers of one and the same class. Here, too, as everywhere, this competition benefits the thing, or the work, which is the object of competition. The greater and more general the competition, the more quickly improvements and inventions are made in the branch of labour, and the higher is the grade of perfection of the labourers themselves.

The position of the different individuals in this struggle for life is evidently very unequal. Starting from the inequality of individuals, which is a recognized fact, we must in all cases necessarily suppose that all the individuals of one and the same species do not have equally favourable prospects. Even at the beginning they are differently placed in this competition by their different strengths and abilities, independently of the fact that the conditions of existence are different, and act differently at every point of the earth's surface. We evidently have an infinite combination of influences, which, together with the original inequality of the individuals during the competition for the conditions of

existence, favour some individuals and prejudice others. The favoured individuals will gain the victory over the others, and while the latter perish more or less early, without leaving any descendants, the former alone will be able to survive and finally to propagate the species. As, therefore, it is clear that in the struggle for life the favoured individuals succeed in propagating themselves, we shall (even as the result of this relation) perceive in the next generation differences from the preceding one. Some individuals of this second generation, though perhaps not all of them, will, by inheritance, receive the individual advantage by which their parents gained the victory over their rivals.

But now—and this is a very important law of inheritance—if such a transmission of a favourable character is continued through a series of generations, it is not simply transmitted in the original manner, but it is constantly increased and strengthened, and in a last generation it attains a strength which distinguishes this generation very essentially from the original parent. Let us, for example, examine a number of plants of one and the same species which grow together in a very dry soil. As the hairs on the leaves of plants are very useful for receiving moisture from the air, and as the hairs on the leaves are very changeable, the individuals possessing the thickest hair on their leaves will have an advantage in this unfavourable locality where the plants have directly to struggle with the want of water, and in addition to this have to compete with one another for the possession of what little water there may be. These alone hold out, while the others possessing less hairy leaves perish; the more hairy ones will be propagated, and their descendants will, on the average, be more distinguished by

their thick and strong hairs than the individuals of the first generation. If this process is continued for several generations in one and the same locality, there will arise at last such an increase of this characteristic, such an increase of the hairs on the surface of the leaf, that an entirely new species seems to present itself. It must here be observed, that in consequence of the interactions of all the parts of every organism, generally one individual part cannot be changed without at the same time producing changes in other parts. If, for instance, in our imaginary example, the number of the hairs on the leaves is greatly increased, a certain amount of nourishment is thereby withdrawn from other parts; the material which might be employed to form flowers or seeds is diminished, and a smaller size of the flower or seed will then be the direct or indirect consequence of the struggle for life, which in the first place only produced a change in the leaves. Thus the struggle for life, in this instance, acts as a means of selecting and transforming. The struggle of the different individuals to obtain the necessary conditions of existence, or, taking it in its widest sense, the inter-relations of organisms to the whole of their surroundings, produce mutations of form such as are produced in the cultivated state by the action of man's selection.

This agency will perhaps appear at first sight small and insignificant, and the reader will not be inclined to concede to the action of such relations the weight which it in reality possesses. I must therefore find space in a subsequent chapter to put forward further examples of the immense and far-reaching power of transformation exhibited in natural selection. For the present I will confine myself to simply placing side by side the two processes of artificial

and natural selection, and clearly explaining the agreement and the differences of the two.

Both natural and artificial selection are quite simple natural, mechanical relations of life, which depend upon the *interaction* of two physiological functions, namely, on *Adaptation* and *Inheritance*, functions which, as such, must again be traced to physical and chemical properties of organic matter. The difference between the two forms of selection consists in this : in artificial selection the will of man makes the selection according to a *plan*, whereas in natural selection, the struggle for life (that universal inter-relation of organisms) acts *without a plan*, but otherwise produces quite the same result, namely, a selection of a particular kind of individuals for propagation. The alterations produced by artificial selection are turned to the advantage of *those who make the selection* ; in natural selection, on the other hand, to the advantage of the *selected organism*.

These are the most essential differences and agreements of the two modes of selection ; it must, however, be further observed that there is another difference, viz. in the duration of time required for the two processes of selection. Man in his artificial selection can produce very important changes in a very short time, while in natural selection similar results are obtained only after a much longer time. This arises from the fact that man can make his selection with much greater care. Man is able with the greatest nicety to pick out individuals from a large number, drop the others, and to employ only the privileged beings for propagation, which is not the case in natural selection. In natural conditions, besides the privileged individuals which first succeed in propagating themselves, some few or many of the less distinguished indi-

viduals will propagate themselves by the side of the former. Moreover, man can prevent the crossing of the original and the new form, which in natural selection is often unavoidable. If such a crossing, that is, a sexual connection, of the new variety with the original forms takes place, the offspring thereby produced generally returns to the original character. In natural selection, such a crossing can be avoided only when the new variety by migration separates from the original and isolates itself.

Natural selection therefore acts much more slowly; it requires much longer periods than the artificial process of selection. But it is an essential consequence of this difference, that the product of artificial selection disappears much more easily, and that the new form returns rapidly to the earlier one, which is not the case in natural selection. The new species arising from natural selection maintain themselves much more permanently, and return much less easily to the original form, than is the case with products of artificial selection, and accordingly maintain themselves during a much longer time than the artificial races produced by man. But these are only subordinate differences, which are explained by the different conditions of natural and artificial selection, and in reality are connected only with differences in the duration of time. The nature of the transformation and the means by which it is produced are entirely the same in both artificial and natural selection. (Gen. Morph. ii. 248).

The thoughtless and narrow-minded opponents of Darwin are never tired of asserting that his theory of selection is a groundless conjecture, or at least an hypothesis which has yet to be proved. That this assertion is completely un-

founded, may be perceived even from the outlines of the doctrine of selection which have just been discussed. Darwin assumes no kind of unknown forces of nature, nor hypothetical conditions, as the acting causes for the transformation of organic forms, but solely and simply the universally recognized vital activities of all organisms, which we term *Inheritance* and *Adaptation*. Every naturalist acquainted with physiology knows that these two phenomena are directly connected with the functions of propagation and nutrition, and, like all other phenomena of life, are purely mechanical processes of nature, that is, they depend upon the molecular phenomena of motion in organic matter. That the interaction of these two functions effect a continual, slow transmutation of organic forms, is a necessary result of the struggle for existence. But this, again, is no more a hypothetical relation, nor one requiring a proof, than is the interaction of Inheritance and Adaptation. The struggle for life is a mathematical necessity, arising from the disproportion between the limited number of places in nature's household, and the excessive number of organic germs. The origin of new species is moreover greatly favoured by the active or passive *migrations* of animals and plants, which takes place everywhere and at all times, without being, however, entitled to rank as *necessary* agents in the process of natural selection.

The origin of new species by natural selection, or, what is the same thing, by the interaction of Inheritance and Adaptation in the struggle for life, is therefore a *mathematical necessity* of nature which needs no further proof. Whoever, in spite of the present state of our knowledge, still seeks for *proofs* for the Theory of Selection, only shows that he either does not thoroughly understand the

theory, or is not sufficiently acquainted with the biological facts—has not the requisite amount of experimental knowledge in Anthropology, Zoology, and Botany.

If, as we maintain, natural selection is the great active cause which has produced the whole wonderful variety of organic life on the earth, all the interesting phenomena of *human life* must also be explicable from the same cause. For man is after all only a most highly-developed vertebrate animal, and all aspects of human life have their parallels, or, more correctly, their lower stages of development in the animal kingdom. The whole history of nations, or what is called “Universal History,” must therefore be explicable by means of “natural selection,”—must be a physico-chemical process, depending upon the interaction of Adaptation and Inheritance in the struggle for life. And this is actually the case. We shall give further proofs of this later on.

It appears of interest here to remark that not only *natural* selection, but also *artificial* selection exercises its influence in many ways in universal history. A remarkable instance of *artificial selection in man*, on a great scale, is furnished by the ancient Spartans, among whom, in obedience to a special law, all newly-born children were subject to a careful examination and selection. All those that were weak, sickly, or affected with any bodily infirmity, were killed. Only the perfectly healthy and strong children were allowed to live, and they alone afterwards propagated the race. By this means, the Spartan race was not only continually preserved in excellent strength and vigour, but the perfection of their bodies increased with every generation. No doubt the Spartans owed their rare degree of masculine strength and rough heroic valour (for which

they are eminent in ancient history) in a great measure to this artificial selection.

Many tribes also among the Red Indians of North America (who at present are succumbing in the struggle for life to the superior numbers of the white intruders, in spite of a most heroic and courageous resistance) owe their rare degree of bodily strength and warlike bravery to a similar careful selection of the newly-born children. Among them, also, all children that are weak or affected with any infirmity are immediately killed, and only the perfectly strong individuals remain in life, and propagate the race. That the race becomes greatly strengthened, in the course of very many generations, by this artificial selection cannot in itself be doubted, and is sufficiently proved by many well known facts.

The opposite of this artificial selection of the wild Redskins and the ancient Spartans is seen in the individual selection which is universally practised in our modern military states, for the purpose of maintaining standing armies, and which, under the name of *military selection*, we may conveniently consider as a special form of selection. Unfortunately, in our day, militarism is more than ever prominent in our so-called "civilization"; all the strength and all the wealth of flourishing civilized states are squandered on its development; whereas the education of the young, and public instruction, which are the foundations of the true welfare of nations and the ennobling of humanity, are neglected and mismanaged in a most pitiable manner. And this is done in states which believe themselves to be the privileged leaders of the highest human intelligence, and to stand at the head of civilization. As is well known, in

order to increase the standing army as much as possible, all healthy and strong young men are annually selected by a strict system of recruiting. The stronger, healthier, and more spirited a youth is, the greater is his prospect of being killed by needle-guns, cannons, and other similar instruments of civilization. All youths that are unhealthy, weak, or affected with infirmities, on the other hand, are spared by the "military selection," and remain at home during the war, marry, and propagate themselves. The more useless, the weaker, or infirmer the youth is, the greater is his prospect of escaping the recruiting officer, and of founding a family. While the healthy flower of youth dies on the battle-field, the feeble remainder enjoy the satisfaction of reproduction and of transmitting all their weaknesses and infirmities to their descendants. According to the laws of transmission by inheritance, there must necessarily follow in each succeeding generation, not only a further extension, but also a more deeply-seated development of weakness of body, and what is inseparable from it, a condition of mental weakness also. This and other forms of artificial selection practised in our civilized states sufficiently explain the sad fact that, in reality, weakness of the body and weakness of character are on the perpetual increase among civilized nations, and that, together with strong, healthy bodies, free and independent spirits are becoming more and more scarce.

To the increasing enervation of modern civilized nations, which is the necessary consequence of military selection, there is further added another evil. The progress of modern medical science, although still little able really to cure diseases, yet possesses and practises more than it used to do the art of prolonging life during lingering, chronic

diseases for many years. Such ravaging evils as consumption, scrofula, syphilis, and also many forms of mental disorders, are transmitted by inheritance to a great extent, and transferred by sickly parents to some of their children, or even to the whole of their descendants. Now, the longer the diseased parents, with medical assistance, can drag on their sickly existence, the more numerous are the descendants who will inherit incurable evils, and the greater will be the number of individuals, again, in the succeeding generation, thanks to that artificial "*medical selection*," who will be infected by their parents with lingering, hereditary disease.

If any one were to venture the proposal, after the examples of the Spartans and Redskins, to kill, immediately upon their birth, all miserable, crippled children to whom with certainty a sickly life could be prophesied, instead of keeping them in life injurious to them and to the race, our so-called "humane civilization" would utter a cry of indignation. But the same "humane civilization" thinks it quite as it should be, and accepts without a murmur, that at the outbreak of every war (and in the present state of civilized life, and in the continual development of standing armies, wars must naturally become more frequent) hundreds and thousands of the finest men, full of youthful vigour, are sacrificed in the hazardous game of battles. The same "humane civilization" at present praises the abolition of capital punishment as a "liberal measure!" And yet capital punishment for incorrigible and degraded criminals is not only just, but also a benefit to the better portion of mankind; the same benefit is done by destroying luxuriant weeds, for the prosperity of a well cultivated garden. As

by a careful rooting out of weeds, light, air, and ground is gained for good and useful plants, in like manner, by the indiscriminate destruction of all incorrigible criminals, not only would the struggle for life among the better portion of mankind be made easier, but also an advantageous artificial process of selection would be set in practice, since the possibility of transmitting their injurious qualities by inheritance would be taken from those degenerate outcasts.

Against the injurious influence of artificial military and medical selection, we fortunately have a salutary counterpoise, in the invincible and much more powerful influence of *natural selection*, which prevails everywhere. For in the life of man, as well as in that of animals and plants, this influence is the most important transforming principle, and the strongest lever for progress and amelioration. The result of the struggle for life is that, in the long run, that which is better, because more perfect, conquers that which is weaker and imperfect. In human life, however, this struggle for life will ever become more and more of an intellectual struggle, not a struggle with weapons of murder. The organ which, above all others, in man becomes more perfect by the ennobling influence of natural selection, is the *brain*. The man with the most perfect understanding, not the man with the best revolver, will in the long run be victorious; he will transmit to his descendants the qualities of the brain which assisted him in the victory. Thus then we may justly hope, in spite of all the efforts of retrograde forces, that the progress of mankind towards freedom, and thus to the utmost perfection, will, by the happy influence of natural selection, become more and more certain.

CHAPTER VIII.

TRANSMISSION BY INHERITANCE AND PROPAGATION.

Universality of Inheritance and Transmission by Inheritance.—Special Evidences of the same.—Human Beings with four, six, or seven Fingers and Toes.—Porcupine Men.—Transmission of Diseases, especially Diseases of the Mind.—Original Sin.—Hereditary Monarchies.—Hereditary Aristocracy.—Hereditary Talents and Mental Qualities.—Material Causes of Transmission by Inheritance.—Connection between Transmission by Inheritance and Propagation.—Spontaneous Generation and Propagation.—Non-sexual or Monogonous Propagation.—Propagation by Self-Division.—Monera and Amœbæ.—Propagation by the formation of Buds, by the formation of Germ-Buds, by the formation of Germ-Cells.—Sexual or Amphigonous Propagation.—Formation of Hermaphrodites.—Distinction of Sexes, or Gonochorism.—Virginal Breeding, or Parthenogenesis.—Material Transmission of Peculiarities of both Parents to the Child by Sexual Propagation.—Difference between Transmission by Inheritance in Sexual and in Asexual Propagation.

THE reader has, in the last chapter, become acquainted with natural selection according to Darwin's theory, as the constructive force of nature which produces the different forms of animal and vegetable species. By natural selection we understand the interaction which takes place in the struggle for life between the *transmission by inheritance* and the *mutability* of organisms, between two physiological functions which are innate in all animals and plants

and which may be traced to other processes of life—the functions of propagation and nutrition. All the different forms of organisms, which people are usually inclined to look upon as the products of a creative power, acting for a definite purpose, we, according to the Theory of Selection, can conceive as the necessary productions of natural selection, working without a purpose,—as the unconscious interaction between the two properties of Mutability and Hereditivity. Considering the importance which accordingly belongs to these vital properties of organisms, we must examine them a little more closely, and employ a chapter with the consideration of Transmission by Inheritance. (Gen. Morph. ii. 170–191).

Strictly speaking, we must distinguish between Hereditivity (Transmissivity) and Inheritance (Transmission). Hereditivity is the power of transmission, the capability of organisms to transfer their peculiarities to their descendants by propagation. Transmission by Inheritance, or Inheritance simply, on the other hand, denotes the exercise of the capability, the actual transmission.

Hereditivity and Transmission by Inheritance are such universal, everyday phenomena, that most people do not heed them, and but few are inclined to reflect upon the operation and import of these phenomena of life. It is generally thought quite natural and self-evident that every organism should produce its like, and that children should more or less resemble their parents. Heredity is usually only taken notice of and discussed in cases relating to some special peculiarity, which appears for the first time in a human individual without having been inherited, and then is transmitted to his descendants. It shows

itself in a specially striking manner in the case of certain diseases, and in unusual and irregular (monstrous) deviations from the usual formation of the body.

Among these cases of the inheritance of monstrous deviations, those are specially interesting which consist in an abnormal increase or decrease of the number five in the fingers or toes of man. It is not unfrequently observed in families through several generations, that individuals have six fingers on each hand, or six toes on each foot. Less frequent is the number of four or seven fingers or toes. The unusual formation arises at first from a single individual who, from unknown causes, is born with an excess of the usual number of fingers and toes, and transmits these, by inheritance, to a portion of his descendants. In one and the same family it has happened that, throughout three, four, or more generations, individuals have possessed six fingers and toes. In a Spanish family there were no less than forty individuals distinguished by this excess. The transmission of the sixth finger or toe is not permanent or enduring in all cases, because six-fingered people always intermarry again with those possessing five fingers. If a six-fingered family were to propagate by pure in-breeding, if six-fingered men were always to marry six-fingered women, this characteristic would become permanent, and a special six-fingered human race would arise. But as six-fingered men usually marry five-fingered women, and *vice versa*, their descendants for the most part show a very mixed numerical relation, and finally, after the course of some generations, revert again to the normal number of five. Thus, for example, among eight children of a six-fingered father and a five-fingered mother, two children may have on both hands and feet six fingers

and toes, four children may have a mixed number, and two children may have the usual number of five on both hands and feet. In a Spanish family, each child except the youngest had the number six on both hands and feet; the youngest, only, had the usual number on both hands and feet, and the six-fingered father of the child refused to recognize the last one as his own.

The power of inheritance, moreover, shows itself very strikingly in the formation and colour of the human skin and hair. It is well known how exactly the nature of the complexion in many families—for instance, a peculiar soft or rough skin, a peculiar luxuriance of the hair, a peculiar colour and largeness of the eyes—is transmitted through many generations. In like manner, peculiar local growths or spots on the skin, the so-called moles, freckles, and other accumulations of pigment which appear in certain places, are frequently transmitted through several generations so exactly, that in the descendants they appear on the same spots on which they existed in the parents. The porcupine men of the Lambert family, who lived in London last century, are especially celebrated. Edward Lambert, born in 1717, was remarkable for a most unusual and monstrous formation of the skin. His whole body was covered with a horny substance, about an inch thick, which rose in the form of numerous thorn-shaped and scale-like processes, more than an inch long. This monstrous formation of the outer skin, or epidermis, was transmitted by Lambert to his sons and grandsons, but not to his granddaughters. The transmission in this instance remained in the male line, as is often the case. In like manner, an excessive development of fat in certain parts of the body is often transmitted

only in the female line. I scarcely need call to mind how exactly the characteristic formation of the face is transmitted by inheritance ; sometimes it remains within the male, sometimes within the female line ; sometimes it is blended in both.

The phenomena of transmission by inheritance of pathological conditions, especially of the different forms of human diseases, are very instructive and generally known. Diseases of the respiratory organs, the glands, and of the nervous system, are specially liable to be transmitted by inheritance. Very frequently there suddenly appears in an otherwise healthy family a disease until then unknown among them ; it is produced by external causes, by conditions of life causing disease. This disease, brought about in an individual by external cause, is propagated and transmitted to his descendants, and some or all of them then suffer from the same disease. In case of diseases of the lungs, for instance in consumption, this sad transmission by inheritance is well known, and it is the same with diseases of the liver, with syphilis, and diseases of the mind. The latter are specially interesting. Just as peculiar characteristic features of man—pride, ambition, frivolity, etc.—are transmitted to the descendants strictly by inheritance, so too are the peculiar abnormal manifestations of mental activity, which are usually called fixed ideas, despondency, imbecility, and generally “diseases of the mind.” This distinctly and irrefragably shows that the soul of man, just as the soul of animals, is a purely mechanical activity, the sum of the molecular phenomena of motion in the particles of the brain, and that it is transmitted by inheritance, together with its substratum, just as every other quality of the body is materially transmitted by propagation.

When this exceedingly important and undeniable fact is mentioned, it generally causes great offence, and yet in reality it is silently and universally acknowledged. For upon what else do the ideas of "hereditary sin," "hereditary wisdom," and "hereditary aristocracy," etc., rest than upon the conviction that the *quality of the human mind* is transmitted by propagation—that is, by a purely *material* process—through the body, from the parents to the descendants? The recognition of this great importance of transmission by inheritance is shown in a number of human institutions, as for example, among many nations in the division into castes, such as the castes of warriors, castes of priests, and castes of labourers, etc. It is evident that the institution of such castes originally arose from the notion of the great importance of hereditary distinctions possessed by certain families, which it was presumed would always be transmitted by the parents to the children. The institution of an hereditary aristocracy and an hereditary monarchy is to be traced to the notion of such a transmission of special excellencies. However, it is unfortunately not only virtues, but also vices that are transmitted and accumulated by inheritance; and if, in the history of the world, we compare the different individuals of the different dynasties, we shall everywhere find a great number of proofs of the transmission of qualities by inheritance, but fewer of transmissions of virtues than of vices. Look only, for example, at the Roman emperors, at the Julii and the Claudii, or at the Bourbons in France, Spain, and Italy!

In fact, scarcely anywhere could we find such a number of striking examples of the remarkable transmission of bodily and mental features by inheritance, as in the history

of the reigning houses in hereditary monarchies. This is specially true in regard to the diseases of the mind previously mentioned. It is in reigning families that mental disorders are hereditary in an unusual degree. Thus Esquirol, distinguished for his knowledge of mental diseases, proved that the number of insane individuals in the reigning houses was, in proportion to the number among the ordinary population, as 60 to 1; that is, that disorders of the brain occur 60 times more frequently in the privileged families of the ruling houses than among ordinary people. If equally accurate statistics were made of the hereditary nobility, the result would probably be that here also we should find an incomparably larger contingent of mental diseases than among the common, ignoble portion of mankind. This phenomenon can scarcely astonish us if we consider what injury these privileged castes inflict upon themselves by their unnatural, one-sided education, and by their artificial separation from the rest of mankind. By this means many dark sides of human nature are specially developed and, as it were, artificially bred, and, according to the laws of transmission by inheritance, are propagated through series of generations with ever-increasing force and dominance.

It is sufficiently obvious from the history of nations how in successive generations of many dynasties, for example, of the princes of Saxon Thuringia and of the Medici, the noble solicitude for the most perfect human accomplishments in science and art were retained and transmitted from father to son; and how, on the other hand, in many other dynasties, for centuries a special partiality for the profession of war, for the oppression of human freedom, and for other rude acts of violence, have been hereditary. In like

manner talents for special mental activities are transmitted in many families for generations, as, for instance, talent for mathematics, poetry, music, sculpture, the investigation of nature, philosophy, etc. In the family of Bach there have been no less than twenty-two eminent musicians. Of course the transmission of such peculiarities of mind depends upon the material process of reproduction, as does the transmission of mental qualities in general. In this case again, the vital phenomenon, the manifestation of force (as everywhere in nature), is directly connected with definite relations in the admixture of the material components of the organism. It is this definite proportion and molecular motion of matter which is transmitted by generation.

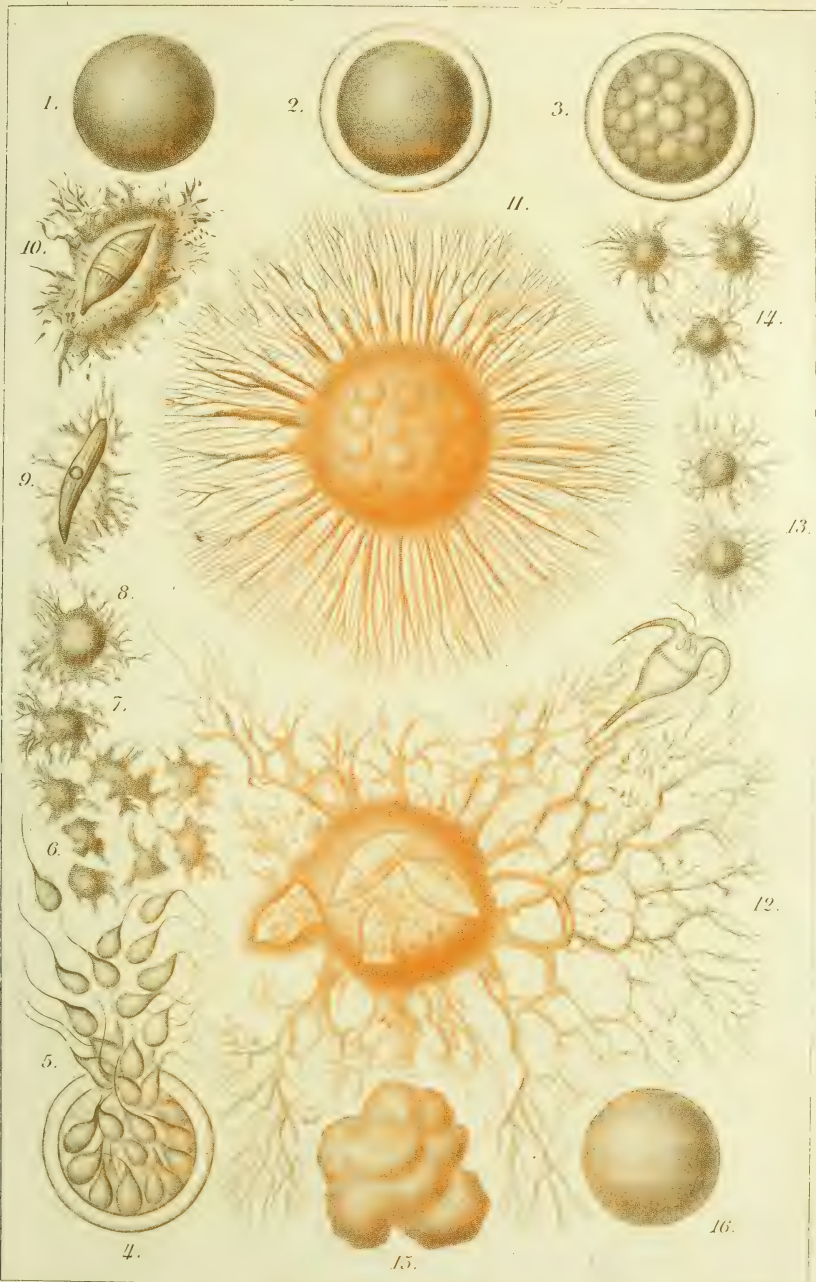
Now, before we examine the numerous, and in some cases most interesting and important, laws of transmission by inheritance, let us make ourselves acquainted with the actual nature of the process. The phenomena of transmission by inheritance are generally looked upon as something quite mysterious, as peculiar processes which cannot be fathomed by natural science, and the causes and actual nature of which cannot be understood. It is precisely in such a case that people very generally assume supernatural influences. But even in the present state of our physiology it can be proved with complete certainty that all the phenomena of inheritance are entirely natural processes, that they are produced by mechanical causes, and that they depend on the material phenomena of motion in the bodies of organisms, which we may consider as a part of the phenomena of propagation. All the phenomena of Heredity and the laws of Transmission by Inheritance can be traced to the material process of *Propagation*.

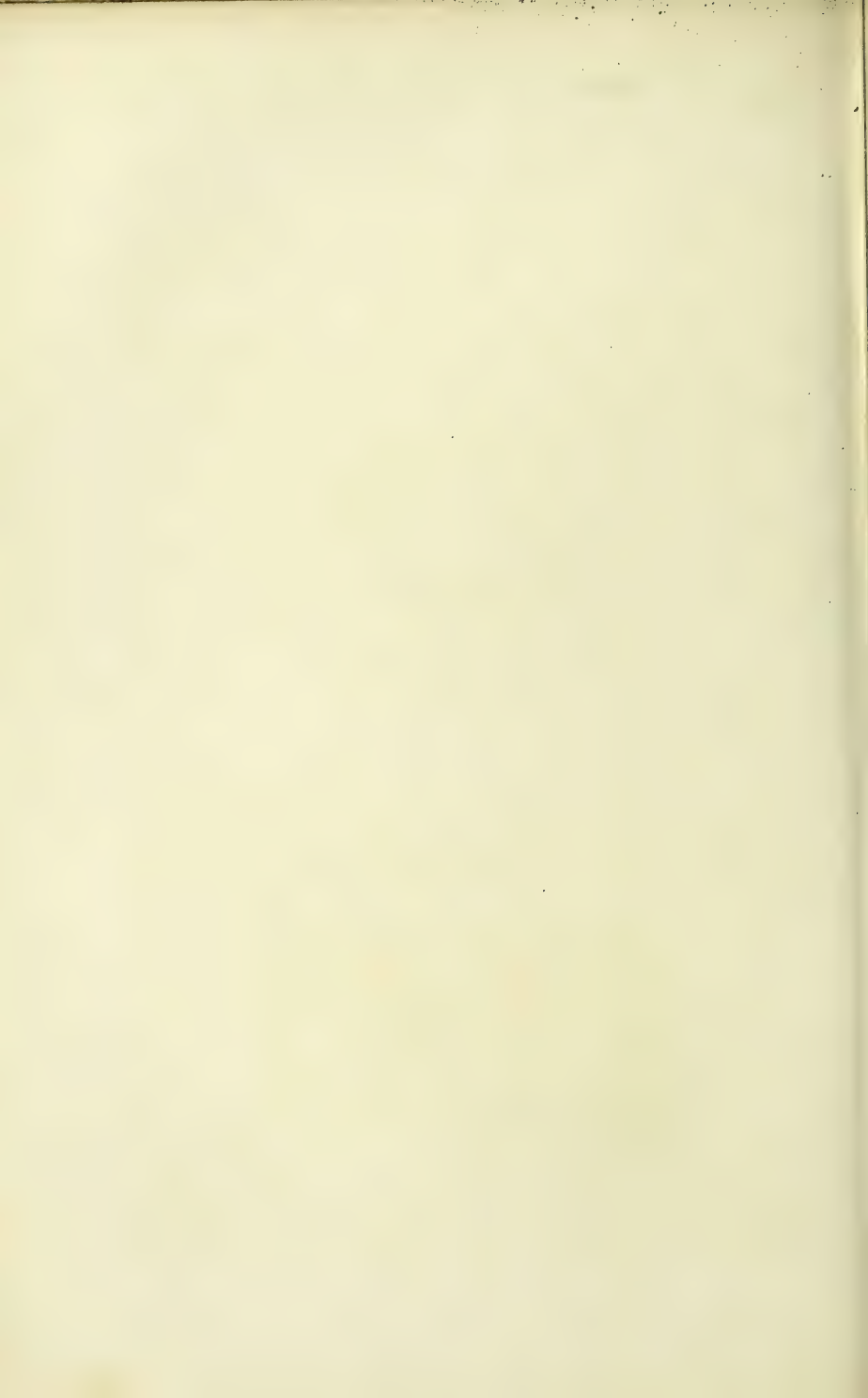
Every organism, every living individual, owes its existence *either* to an act of unparental or *Spontaneous Generation* (*Generatio Spontanea Archigonia*), or to an act of Parental Generation or *Propagation* (*Generatio Parentalis, Tocogonia*). In a future chapter we shall have to consider Spontaneous Generation, or Archigony. At present we must occupy ourselves with Propagation, or Tocogony, a closer examination of which is of the utmost importance for understanding transmission by inheritance. Most of my readers probably only know those phenomena of Propagation which are seen universally in the higher plants and animals, the processes of Sexual Propagation, or Amphigony. The processes of Non-sexual Propagation, or Monogony, are much less generally known. The latter, however, are far more suited to throw light upon the nature of transmission by inheritance in connection with propagation.

For this reason, we shall first consider only the phenomena of *non-sexual* or *monogonic propagation* (*Monogonia*). This appears in a variety of different forms, as for example, self-division, formation of buds, the formation of germ-cells or spores (*Gen. Morph. ii. 36-58*). It will be most instructive, first, to examine the propagation of the simplest organisms known to us, which we shall have to return to later, when considering the question of spontaneous generation. These very simplest of all organisms yet known, and which, at the same time, are the simplest imaginable organisms, are the *Monera* living in water; they are very small living corpuscles, which, strictly speaking, do not at all deserve the name of organism. For the designation "organism," applied to living creatures, rests upon the idea that every living natural body is com-

posed of organs, of various parts, which fit into one another and work together (as do the different parts of an artificial machine), in order to produce the action of the whole. During late years we have become acquainted with *Monera*, organisms which are, in fact, not composed of any organs at all, but consist entirely of shapeless, simple, homogeneous matter. The entire body of one of these *Monera*, during life, is nothing more than a shapeless, mobile, little lump of mucus or slime, consisting of an albuminous combination of carbon. Simpler or more imperfect organisms we cannot possibly conceive.

The first complete observations on the natural history of a *Moneron* (*Protogenes primordialis*) were made by me at Nice, in 1864. Other very remarkable *Monera* I examined later (1866) in Lanzarote, one of the Canary Islands, and in 1867 in the Straits of Gibraltar. The complete history of one of these *Monera*, the orange-red *Protomyxa aurantiaca*, is represented in Plate I, and its explanation is given in the Appendix. I have found some curious *Monera* also in the North Sea, off the Norwegian coast, near Bergen. Cienkowski has described (1865) an interesting *Moneron* from fresh waters, under the name of *Vampyrella*. But perhaps the most remarkable of all *Monera* was discovered by Huxley, the celebrated English zoologist, and called *Bathybius Hæckelii*. "*Bathybius*" means, living in the deep. This wonderful organism lives in immense depths of the ocean, which are over 12,000—indeed, in some parts 24,000 feet below the surface, and which have become known to us within the last ten years, through the laborious investigations made by the English. There, among the numerous *Polythalamia* and





Radiolaria which inhabit the fine calcareous mud of these abysses, the Bathybius is found in great quantities, sometimes in the shape of roundish, formless lumps of mucus, sometimes in the form of a network of mucus, covering fragments of stone and other objects. Small particles of chalk are frequently embedded in these mucous gelatinous masses, and are, perhaps, products of their secretion. The entire body of this remarkable Bathybius consists solely of shapeless plasma, or protoplasm, as in the case of the other Monera—that is, it consists of the same albuminous combination of carbon, which in infinite modifications is found in all organisms, as the essential and never-failing seat of the phenomena of life. I have given a detailed description and drawing of the Bathybius and other Monera in my “*Monographie der Moneren*,” 1870,¹⁵ from which the drawing in Fig. 9 is taken.

In a state of rest most Monera appear as small globules of mucus or slime, invisible, or nearly so, to the naked eye; they are at most as large as a pin's head. When the Moneron moves itself, there are formed on the upper surface of the little mucous globule, shapeless, fingerlike processes, or very fine radiated threads; these are the so-called false feet, or pseudopodia. The false feet are simple, direct continuations of the shapeless albuminous mass, of which the whole body consists. We are unable to perceive different parts in it, and we can give a direct proof of the absolute simplicity of the semi-fluid mass of albumen, for with the aid of the microscope we can follow the Moneron as it takes in nourishment. When small particles suited for its nourishment—for instance, small particles of decayed organic bodies or microscopic plants and infusoria—acci-

dentially come into contact with the Moneron, they remain hanging to the sticky semi-fluid globule of mucus, and here create an irritation, which is followed by a strong afflux of the mucous substance, and, in consequence, they become finally completely inclosed by it, or are drawn into the body of the Moneron by displacement of the several albuminous particles, and are there digested, being absorbed by simple diffusion (endosmosis).

Just as simple as the process of nutrition is the *propagation* of these primitive creatures, which in reality we can neither call animals nor plants. All Monera propagate themselves only in an asexual manner by monogony; and in the simplest case, by that kind of monogony which we place at the head of the different forms of propagation, that is, by self-division. When such a little globule, for example a Protamœba or a Protogenes, has attained a certain size by the assimilation of foreign albuminous matter, it falls into two pieces; a pinching in takes place, contracting the middle of the globule on all sides, and finally leads to the separation of the two halves (compare Fig. 1.). Each half

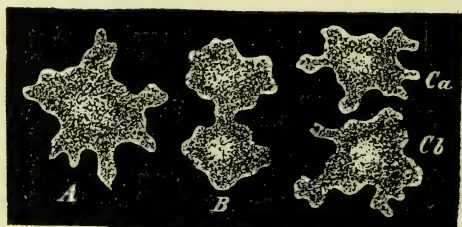


FIG. 1.—Propagation of the simplest organism, a Moneron, by self-division. A. The entire Moneron, a Protamœba. B. It falls into two halves by a contraction in the middle. C. Each of the two halves has separated from the other, and now represents an independent individual.

then becomes rounded off, and now appears as an independent individual, which commences anew the simple course of the vital phenomena of nutrition and propagation. In other Monera (*Vampyrella*), the body in the process of propagation does not fall into two, but into four equal pieces, and in others, again (*Protomonas*, *Protomyxa*, *Myxastrum*), at once into a number of small globules of mucus, each of which again, by simple growth, becomes like the parent body. Here it is evident that the process of *propagation* is nothing but a growth of the organism beyond its own individual limit of size.

The simple method of propagation of the Moneron by self-division is, in reality, the most universal and most widely spread of all the different modes of propagation; for by the same simple process of division, *cells* also propagate themselves. Cells are those simple organic individuals, a large number of which constitute the bodies of most organisms, the human body not excepted. With the exception of the organisms of the lowest order, which have not even the perfect form of a cell (*Monera*), or during life only represent a single cell (many *Protista* and single-celled plants), the body of every organic individual is composed of a great number of cells. Every organic cell is to a certain degree an independent organism, a so-called "elementary organism," or an "individual of the first order." Every higher organism is, in a measure, a society or a state of such variously shaped elementary individuals, variously developed by division of labour.³⁹ Originally every organic cell is only a single globule of mucus, like a Moneron, but differing from it in the fact that the homogeneous albuminous substance has separated itself into two different parts, a firmer albu-

minous body, the *cell-kernel* (nucleus), and an external, softer albuminous body, the *cell-substance* or *body* (protoplasma). Besides this, many cells later on form a third (frequently absent) distinct part, inasmuch as they cover themselves with a capsule, by exuding an outer pellicle or *cell-membrane* (membrana). All other forms of cells, besides these, are of subordinate importance, and are of no further interest to us here.

Every organism composed of many cells was originally a single cell, and it becomes many-celled owing to the fact that the original cell propagates itself by self-division, and that the new individual cells originating in this manner remain together, and by division of labour form a community or a state. The forms and vital phenomena of all many-celled organisms are merely the effect or the expression of all the forms and vital phenomena of all the individual cells of which they are composed. The egg, from which most animals and plants are developed, is a simple cell.

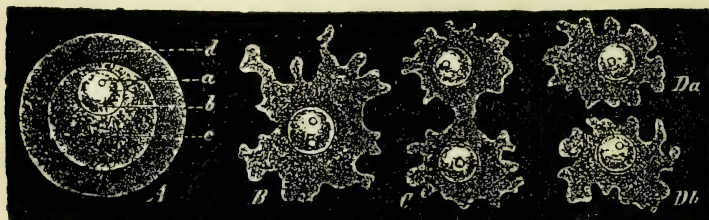


FIG. 2.—Propagation of a single-celled organism, *Amœba sphærococcus*, by self-division. A. The enclosed *Amœba*, a simple globular cell consisting of a lump of protoplasm (c), which contains a kernel (b) and a kernel speck (a), and is surrounded by a cell-membrane or capsule. B. The free *Amœba*, which has burst and left the cyst or cell-membrane. C. It begins to divide by its kernel forming two kernels, and by the cell-substance between the two becoming contracted. D. The division is completed by the cell-substance likewise falling into two halves (*Da* and *Db*).

The single-celled organisms, that is, those which during life retain the form of a single cell, for example the *Amœbæ*, as a rule propagate themselves in the simplest way by self-division. This process differs from the previously described self-division of the *Moneron* only in the fact that at the commencement the firmer cell-kernel (nucleus) falls into two halves, by a pinching in at its middle. The two young kernels separate from each other and act now as two distinct centres of attraction upon the surrounding softer albuminous matter, that is, the cell-substance (protoplasm). By this process finally the latter also divides into two halves, and there now exist two new cells, which are like the mother cell. If the cell was surrounded by a membrane, this either does not divide at all, as in the case of egg-cleavage (Fig. 3, 4), or it passively follows the active pinching in of the protoplasm; or, lastly, every new cell exudes a new membrane for itself.

The non-independent cells which remain united in communities or states, and thus constitute the body of higher organisms, are propagated in the same manner as are independent single-celled organisms, for example, *Amœba* (Fig. 2). Just as in that case, the cell with which most animals and plants commence their individual existence, namely, the egg, multiplies itself by simple division. When an animal, for instance a mammal (Fig. 3, 4), develops out of an

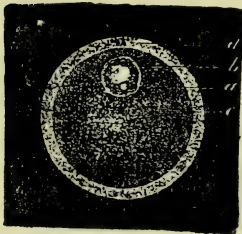


FIG. 3.—Egg of a mammal (a simple cell).
a. The small kernel speck or nucleolus (the so-called germ-spot of the egg). *b.* Kernel or nucleus (the so-called germ-bladder of the egg). *c.* Cell-substance or protoplasm (the so-called yolk of the egg). *d.* Cell-capsule or membrane (membrane of the yolk) of the egg; called in mammals, on account of its transparency, *Membrana pellucida*.

egg, this process of development always begins by the simple egg-cell (Fig. 3) forming an accumulation of cells

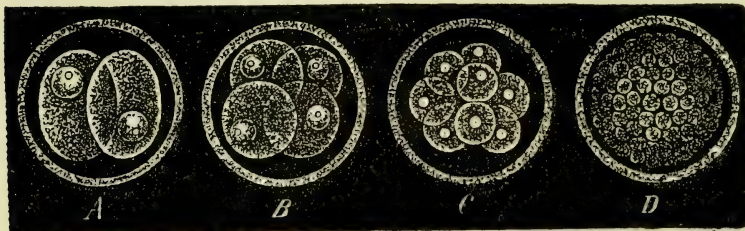


FIG. 4.—First commencement of the development of a mammal's egg, the so-called "cleavage of the egg" (propagation of the egg-cell by repeated self-division). *A*. The egg, by the formation of the first furrow, falls into two cells. *B*. These separate by division into four cells. *C*. The latter have divided into eight cells. *D*. By repeated division a globular accumulation of numerous cells has arisen.

(Fig. 4) by continued self-division. The outer covering, or cell membrane, of the globular egg remains undivided. First, the cell-kernel of the egg (the so-called germinal vesicle) divides itself into two kernels, then follows the cell-substance (the yolk of the egg) (Fig. 4 *A*). In like manner, the two cells, by continued self-division, separate into four (Fig. 4 *B*), these into eight (Fig. 4 *C*), into sixteen, thirty-two, etc., and finally there is produced a globular mass of very numerous little cells (Fig. 4 *D*). These now, by further increase and heterogeneous development (division of labour), gradually build up the compound many-celled organism. Every one of us, at the commencement of our individual development, has undergone the very same process as that represented in Fig. 4. The egg of a mammal—represented in Fig. 3, and its development in Fig. 4—might as well be that of a man, as of an ape, dog, horse, or any other placental mammal.

Now, when one examines this simplest form of propagation, this self-division, it surely cannot be considered wonderful that the products of the division of the original organism should possess the same qualities as the parental individual. For they are parts or halves of the parental organism, and the matter or substance in both halves is the same, and as both the young individuals have received an equal amount and the same quality of matter from the parent individual, one can but consider it natural that the vital phenomena, the physiological qualities should be the same in both children. In fact, in regard to their form and substance, as well as to their vital phenomena, the two produced cells can in no respect be distinguished from one another, or from the mother cell. They have *inherited* from her the same nature.

But this same simple propagation by self-division is not only confined to simple cells—it is the same also in the higher many-celled organisms; for example, in the coral zoophytes. Many of them which exhibit a high complexity of composition and organization, nevertheless, propagate themselves by simple division. In this case the whole organism, with all its organs, falls into two equal halves as soon as by growth it has attained a certain size. Each half again develops itself, by growth, into a complete individual. Here, again, it is surely self-evident that the two products of division will share the qualities of the parental organism, as they themselves are in fact halves of that parent.

Next to propagation by division we come to propagation by the *formation of buds*. This kind of monogony is exceedingly widely spread. It occurs both in the case of simple cells (though not frequently) and in the higher organ-

isms composed of many cells. The formation of buds is universal in the vegetable kingdom, less frequent in the animal kingdom. However, here also it occurs in the tribe of Plant-like Animals, especially among the Coral Zoophytes, and among the greater portion of the Hydroid Polyps very frequently, further also among some worms (Planarian Worms, Ring-Worms, Moss Animals, Tunicates). Most branching animal-trees or colonies, which are exceedingly like branching plants, arise like those plants, by the formation of buds.

Propagation by the *formation of buds* (Gemmatio) is essentially distinguished from propagation by division, in the fact that the two organisms thus produced by budding are not of equal age, and therefore at first are not of equal value, as they are in the case of division. In division we cannot clearly distinguish either of the two newly produced individuals as the parental, that is as the producer, because, in fact, both have an equal share in the composition of the original parental individual. If, on the other hand, an organism sends out a bud, then the latter is the child of the former. The two individuals are of unequal size and of unequal form. If, for instance, a cell propagates itself by the formation of buds, we do not see the cell fall into two equal halves, but there appears at one point of it a protuberance, which becomes larger and larger, more or less separates itself from the parental cell, and then grows independently. In like manner we observe in the budding of a plant or animal, that a small local growth arises on a part of the mature individual, which growth becomes larger and larger, and likewise more or less separates itself from the parental organism by an independence in its growth. The bud, after

it has attained a certain size, may either completely separate itself from the parental individual, or it may remain connected with it and form a stock or colony, whilst at the same time its life may be quite independent of that of its parent. While the growth which starts the propagation, in the case of self-division, is a total one affecting the whole body, it is in the formation of buds only partial, affecting merely a portion of the parental organism. But here, also, the bud—the newly-produced individual which remains so long most directly connected with the parental organism, and which proceeds from it—retains the essential qualities and the original tendency of development of its parent.

A third mode of non-sexual propagation, that of the *formation of germ-buds* (Polysporogonia), is intimately connected with the formation of buds. In the case of the lower, imperfect organisms, among animals, especially in the case of the Plant-like animals and Worms, we very frequently find that in the interior of an individual composed of many cells, a small group of cells separates itself from those surrounding it, and that this small isolated group gradually develops itself into an individual, which, becomes like the parent, and sooner or later comes out of it. Thus, for example, in the body of the Fluke-worms (Trematodes) there often arise numerous little bodies consisting of many cells, that is *germ-buds*, or *polyspores*, which at an early stage separate themselves completely from the parent body, and leave it when they have attained a certain stage of development.

The formation of germ-buds is evidently but little different from real budding. But, on the other hand, it is connected with a fourth kind of non-sexual propagation, which almost

forms a transition to sexual reproduction, namely, the *formation of germ-cells* (Monosporogonia), which is often briefly called formation of spores (sporogonia). In this case it is no longer a group of cells, but a single cell, which separates itself from the surrounding cells in the interior of the producing organism, and which only becomes [further developed after it has come out of its parent. After this *germ-cell*, or monospore (or, briefly, spore), has left the parental individual, it multiplies by division, and thus forms a many-celled organism, which by growth and gradual development attains the hereditary qualities of the parental organism. This occurs very generally among lower plants (Cryptogama).

Although the formation of germ-cells very much resembles the formation of germ buds, it evidently and very essentially differs from the latter, and also from the other forms of non-sexual propagation which have previously been mentioned, by the fact that only a very small portion of the producing organism takes part in the propagation and, accordingly, in the transmission by inheritance. In the case of self-division, where the whole organism falls into two halves, in the formation of buds, where a considerable portion of the whole body, already more or less developed, separates from the producing individual, we easily understand that the forms and vital phenomena should be the same in the producing and produced organism. It is much more difficult to understand in the formation of germ-buds, and more difficult still in the formation of germ-cells, how this very small, quite undeveloped portion of the body, this group of cells, or this single cell, not only directly takes with it certain parental qualities into its independent existence, but also after its

separation from the parental individual develops into a many-celled body, and in this repeats the forms and vital phenomena of the original producing organism. This last form of monogonic propagation—that of the germ cells, or spore-formation—leads us directly to a form of propagation which is the most difficult of all to explain, namely, sexual propagation.

Sexual or amphigonic propagation (Amphigonia) is the usual method of propagation among all higher animals and plants. It is evident that it has only developed, at a very late period of the earth's history, from non-sexual propagation, and apparently in the first instance from the method of propagation by germ-cells. In the earliest periods of the organic history of the earth, all organisms propagated themselves in a non-sexual manner, as numerous lower organisms still do, especially all those which are at the lowest stage of organization, and which, strictly speaking, can be considered neither as animals nor as plants, and which therefore, as primary creatures, or Protista, are best excluded from both the animal and vegetable kingdoms. In the case of the higher animals and plants, the increase of individuals, as a rule, is at present brought about in the majority of cases by sexual propagation.

In all the chief forms of non-sexual propagation mentioned above—in fission, in the formation of buds, germ buds, and germ cells—the separated cell or group of cells was able by itself to develop into a new individual, but in the case of sexual propagation the cell must first be fructified by another generative substance. The fructifying male sperm must first mix with the female germ-cell (the egg) before the latter can develop into a new individual. These two

different generative substances, the male sperm and the female egg, are either produced by one and the same individual hermaphrodite (Hermaphroditismus), or by two different individuals (sexual separation, Gonochorismus) (Gen. Morph. ii. 58, 59).

The simpler and more ancient form of sexual propagation is through double-sexed individuals (Hermaphroditismus). It occurs in the great majority of plants, but only in a minority of animals, for example, in the garden snails, leeches, earth-worms, and many other worms. Every single individual among hermaphrodites produces within itself materials of both sexes—eggs and sperm. In most of the higher plants every blossom contains both the male organ (stamens and anther) and the female organs (style and germ). Every garden snail produces in one part of its sexual gland eggs, and in another part sperm. Many hermaphrodites can fructify themselves; in others, however, copulation and reciprocal fructification of both hermaphrodites is necessary for causing the development of the eggs. This latter case is evidently a transition to sexual separation.

Sexual separation (Gonochorismus,) which characterizes the more complicated of the two kinds of sexual reproduction, has evidently been developed from the condition of hermaphroditism at a late period of the organic history of the world. It is at present the universal method of propagation of the higher animals, and occurs, on the other hand, only in the minority of plants (for example, in many aquatic plants, *e.g.* Hydrocharis, Vallisneria; and in trees, *e.g.* Willows, Poplars). Every organic individual, as a non-hermaphrodite (Gonochoristus), produces within itself only

one of two generative substances, either the male or the female. The female individuals, both in animals and plants, produce eggs or egg-cells. The eggs of plants in the case of flowering plants (Phanerogama), are commonly called "embryo sacs"; in the case of flowerless plants (Cryptogama), "fruit spores." In animals, the male individual secretes the fructifying sperm (sperma); in plants, the corpuscles, which correspond to the sperm. In the Phanerogama, these are the pollen grains, or flower-dust; in the Cryptogama, a sperm, which, like that of most animals, consists of floating vibratile cells actively moving in a fluid—the zoosperms, spermatozoa, or sperm-cells.

The so-called *virginal reproduction* (Parthenogenesis) offers an interesting form of transition from sexual reproduction to the non-sexual formation of germ-cells (which most resembles it); it has been demonstrated to occur in many cases among Insects, especially by Siebold's excellent investigations. In this case germ-cells, which otherwise appear and are formed exactly like egg-cells, become capable of developing themselves into new individuals without requiring the fructifying seed. The most remarkable and most instructive of the different parthenogenetic phenomena are furnished by those cases in which the same germ-cells, according as they are fructified or not, produce different kinds of individuals. Among our common honey bees, a male individual (a drone) arises out of the eggs of the queen, if the egg has not been fructified; a female (a queen, or working bee), if the egg has been fructified. It is evident from this, that in reality there exists no wide chasm between sexual and non-sexual reproduction, but that both modes of reproduction are directly

connected. The parthenogenesis of Insects must probably be regarded as a *relapse* from the sexual mode of propagation (possessed by the original parents of the insects) to the earlier condition of non-sexual propagation. (Gen. Morph. ii. 86). In any case, however, sexual reproduction, both in plants and animals, which seems such a wonderful process, has only arisen at a later date out of the more ancient process of non-sexual reproduction. In both cases heredity is a necessary part of the phenomenon.

In all the different modes of propagation the essential point of the process is invariably a detachment of a portion of the parental organism possessing the capability of leading an individual, independent existence. We may, therefore, in all cases expect, *a priori*, that the produced individuals—which are, in fact, as is commonly said, “the flesh and blood” of the parents—will receive the vital characteristics and qualities of form which the parental individuals possess. It is simply a larger or smaller quantity of the parental material, in fact of its albuminous protoplasm, or cell-substance, which passes to the produced individual. But together with the material, its vital properties—that is, the molecular motions of the plasma—are transmitted, which then manifest themselves in its form. Inheritance by sexual breeding loses very much of the mysterious and wonderful character which it at first sight possesses for the uninitiated, if we consider the above-mentioned series of the different modes of propagation, and their connection one with another. It at first appears exceedingly wonderful that in the sexual propagation of man, and of all higher animals, the small egg, the minute cell, often invisible to the naked eye, is able to transfer to the produced organism all the qualities

of the maternal organism, and, no less mysterious, that at the same time the essential qualities of the paternal organism are transferred to the offspring by means of the male sperm, which fructifies the egg-cell by means of a viscid substance in which minute thread-like cells or zoosperms move about. But as soon as we compare the connected stages of the different kinds of propagation, in which the produced organism separates itself more and more as a distinct growth from the parental individual, and more or less early enters upon its independent career; as soon as we consider, at the same time, that the growth and development of every higher organism only depends upon the increase of the cells composing it—that is, upon their simple propagation by division—it becomes quite evident that all these remarkable processes belong to one series.

The life of every organic individual is nothing but a connected chain of very complicated material phenomena of motion. These motions must be considered as changes in the position and combination of the molecules, that is, of the smallest particles of animated matter (of atoms placed together in the most varied manner). The specific, definite tendency of these orderly, continuous, and inherent motions of life depends, in every organism, upon the chemical mingling of the albuminous generative matter to which it owes its origin. In man, as in the case of the higher animals which propagate themselves in a sexual manner, the individual vital motion commences at the moment in which the egg-cell is fructified by the spermatric filaments of the seed, in which process both generative substances actually mix; and here the tendency of the vital motion is determined by the specific, or more

accurately, by the individual nature of the sperm as well as of the egg. There can be no doubt as to the purely mechanical material nature of this process. But here we stand full of wonder and astonishment before the infinite and inconceivable delicacy of this albuminous matter. We are amazed at the undeniable fact that the simple egg-cell of the maternal organism, and a single paternal sperm-thread, transfer the molecular individual vital motion of these two individuals to the child so accurately, that afterwards the minutest bodily and mental peculiarities of both parents reappear in it.

Here we stand before a mechanical phenomenon of nature of which Virchow, whose genius founded the "cellular pathology," says with full justice: "If the naturalist cared to follow the custom of historians and preachers, and to clothe phenomena, which are in their way unique, with the hollow pomp of ponderous and sounding words, this would be the opportunity for him; for we have now approached one of those great mysteries of animal nature, which encircle the region of animal life as opposed to all the rest of the world of phenomena. The question of the formation of cells, the question of the excitation of a continuous and equable motion, and, finally, the questions of the independence of the nervous system and of the soul—these are the great problems on which the human mind can measure its strength." To comprehend the relation of the male and female to the egg-cell is almost as much as to solve all those mysteries. The origin and development of the egg-cell in the mother's body, the transmission of the bodily and mental peculiarities of the father to it by his seed, touch upon all the questions which the human

mind has ever raised about man's existence. And, we add, these most important questions are solved, by means of the Theory of Descent, in a purely mechanical and purely monistic sense !

There can then be no further doubt that, in the sexual propagation of man and all higher organisms, inheritance, which is a purely mechanical process, is directly dependent upon the material continuity of the producing and produced organism, just as is the case in the simplest non-sexual propagation of the lower organisms. However, I must at once take this opportunity of drawing attention to an important difference which inheritance presents in sexual and non-sexual propagation. It is a fact long since acknowledged, that the individual peculiarities of the producing organism are much more accurately transmitted to the produced organism by non-sexual than by sexual propagation. Gardeners have for a long time made use of this fact in many ways. When, for instance, a single individual of a species of tree with stiff, upright branches accidentally produces down-hanging branches, a gardener, as a rule, cannot transmit this peculiarity by sexual, but only by non-sexual propagation. The twigs cut off such a weeping tree and planted as cuttings or slips, afterwards produce trees having likewise hanging branches, as, for example, the weeping willows and beeches. Seedlings, on the other hand, which have been reared out of the seed of such a weeping tree, generally have the original stiff and upright form of branches possessed by their ancestors. The same may be observed in a very striking manner in the so-called "copper-coloured trees," that is, varieties of trees which are characterized by a red or reddish brown

colour of the leaves. Off-shoots from such copper-coloured trees (for example, the copper beech), which have been propagated by cuttings in a non-sexual manner, show the peculiar colour and nature of the leaves which distinguished the parental individual, while others reared from seeds of such a copper-coloured tree return to the green-coloured condition of leaf.

This difference in inheritance will seem very natural when we consider that the material connection between the producing and produced individuals is much closer and lasts much longer in non-sexual than in sexual propagation. The special tendency of the molecular motion of life can therefore fix itself much longer and more thoroughly in the filial organism, and be more strictly transmitted by non-sexual than by sexual propagation. All these phenomena, considered in connection, clearly prove that the transmission of bodily and mental peculiarities is a purely material and mechanical process. By propagation a greater or lesser quantity of albuminous particles, and together with them the individual form of motion inherent in these molecules of protoplasm, are transmitted from the parental organism to the offspring. As this form of motion remains continuous, the more delicate peculiarities inherent in the parental organism must sooner or later reappear in the filial organism.

CHAPTER IX.

LAWS OF TRANSMISSION BY INHERITANCE.
ADAPTATION AND NUTRITION.

Distinction between Conservative and Progressive Transmission by Inheritance.—Laws of Conservative Transmission : Transmission of Inherited Characters.—Uninterrupted or Continuous Transmission.—Interrupted or Latent Transmission.—Alternation of Generations.—Relapse.—Degeneracy.—Sexual Transmission.—Secondary Sexual Characters.—Mixed or Amphigonous Transmission.—Hybrids.—Abridged or Simplified Transmission.—Laws of Progressive Inheritance : Transmission of Acquired Characters.—Adapted or Acquired Transmission.—Fixed or Established Transmission.—Homochronous Transmission (Identity in Epoch).—Homotopic Transmission (Identity in Part).—Adaptation and Mutability.—Connection between Adaptation and Nutrition.—Distinction between Indirect and Direct Adaptation.

IN the last chapter we considered Transmission by Inheritance, one of the two universal vital activities of organisms, Adaptation and Inheritance, which by their interaction produce the different species of organisms, and we have endeavoured to trace this very mysterious vital activity to a more general physiological function of organisms, namely, to Propagation. This latter in its turn, like other vital phenomena of animals and plants, depends on physical and chemical relations. It is true they appear at times exceedingly complicated, but can nevertheless in reality be traced to simple mechanical causes—that is, to the relations

of attraction and repulsion in the particles or molecules—in fact, to the motional phenomena of matter.

Now, before we turn our attention to the second function, the phenomenon of Adaptation or Mutability, which counteracts the Transmission by Inheritance, it seems appropriate first to cast one more glance at the various manifestations of Heredity, which we may perhaps even now denominate the “*laws of transmission by inheritance*.” Unfortunately, up to the present time very little has been done for this most important subject, either in zoology or in botany, and almost all we know of the different laws of inheritance is confined to the experiences of gardeners and farmers. It is not therefore to be wondered at, that on the whole these exceedingly interesting and important phenomena have not been investigated with desirable scientific accuracy, or reduced to the form of scientific laws. Accordingly, what I shall relate of the different laws of transmission are only some preliminary fragments taken out of the infinitely rich store which lies open to our inquiry.

We may first divide all the different phenomena of inheritance into two groups, which we may distinguish as the transmission of *inherited* characters, and the transmission of *acquired* characters; and we may call the former the *conservative* transmission, and the latter the *progressive* transmission by inheritance. This distinction depends upon the exceedingly important fact that the individuals of every species of animals and plants can transmit to their descendants, not only those qualities which they themselves have inherited from their ancestors, but also the peculiar, individual qualities which they have acquired during their own life. The latter are transmitted by progressive, the

former by conservative inheritance. We have now first to examine the phenomena of *conservative inheritance*, that is, the transmission of such qualities as the organism has already received from its parents or ancestors. (Gen. Morph. ii. 180.)

Among the phenomena of conservative inheritance we are first struck by that which is its most general law, and which we may term the *law of uninterrupted or continuous transmission*. It is so universal among the higher animals and plants, that the uninitiated might overestimate its action and consider it as the only normal law of transmission by inheritance. This law simply consists in the fact that among most species of animals and plants, every generation is, on the whole, like the preceding—that the parents are as like the grandparents as they are like the children. “Like produces like,” as is commonly said, but more accurately “similar things produce similar things.” For, in reality, the descendants of every organism are never absolutely equal in all points, but only similar in a greater or less degree. This law is so generally known, that I need not give any examples of it.

The *law of interrupted or latent transmission* by inheritance, which might also be termed alternating transmission, is in a measure opposed to the preceding law. This important law appears principally active among many lower animals and plants, and manifests itself in contrast to the former in the fact that the offspring are not like their parents, but very dissimilar, and that only the third or a later generation becomes similar to the first. The grandchildren are like the grandparents, but quite unlike the parents. This is a remarkable phenomenon, and, as is well

known, occurs also very frequently, though in a less degree, in human families. Every one of my readers doubtless knows some members of a family who, in this or that peculiarity, much more resemble the grandfather or grandmother than the father or mother. Sometimes it lies in bodily peculiarities, for example, features of face, colour of hair, size of body—sometimes in mental qualities, for example, temperament, energy, understanding—which are transmitted in this manner. This fact may be observed in domestic animals as well as in the case of man. Among the domestic animals most liable to vary—as the dog, horse, and ox—breeders very frequently find that the product by breeding resembles the grandparents far more than it does its own parental organism. If we express this general law and the succession of generations by the letters of the alphabet, then $A = C = E$, whilst $B = D = F$, and so on.

This very remarkable fact appears in a more striking way in the lower animals and plants than in the higher, and especially in the well-known phenomenon of *alternation of generations* (metagenesis). Here we very frequently find—for example, among the Planarian worms, sea-squirts or Tunicates, Zoophytes, and also among ferns and mosses—that the organic individual in the first place produces, by propagation, a form completely different from the parental form, and that only the descendants of this generation, again, become like the first. This regular change of generation was discovered by the poet Chamisso, on his voyage round the world in 1819, among the *Salpæ*, cylindrical tunicates, transparent like glass, which float on the surface of the sea. Here the larger generation, the in-

dividuals of which live isolated and possess an eye of the form of a horse-shoe, produce in a non-sexual manner (by the formation of buds) a completely different and smaller generation. The individuals of this second smaller generation live united in chains and possess a cone-shaped eye. Every individual of such a chain produces, in a sexual manner (hermaphrodite) again, a non-sexual solitary form of the first and larger generation. Among the Salpæ, therefore, it is always the first, third, and fifth generation, and in like manner the second, fourth, and sixth generations, that are entirely like one another. However, it is not always only one, but in other cases a number of generations, which are thus leapt over; so that the first generation resembles the fourth and seventh, the second resembles the fifth and eighth, the third resembles the sixth and ninth, and so on. Three different generations alternate with one another; for example, among the neat *little sea-buoys* (*Doliolum*), small tunicates closely related to the Salpæ. In this case it is $A = D = G$, further, $B = E = H$, and $C = F = I$. Among the plant-lice (*Aphides*), each sexual generation is followed by a succession of from eight to ten or twelve non-sexual generations, which are like one another, but differ from the sexual generations. Then, again, a sexual generation reappears like the one long before vanished.

If we further follow this remarkable law of latent or interrupted inheritance, and take into consideration all the phenomena appertaining to it, we may comprise under it also the well-known phenomena of *reversion*. By the term "reversion" or "atavism" we understand the remarkable fact known to all breeders of animals, that occasionally single and individual animals assume a form which has not

existed for many generations, but belongs to a generation which has long since disappeared. One of the most remarkable instances of this kind is the fact that in some horses there sometimes appear singular dark stripes, similar to those of the zebra, quagga, and other wild species of African horses. Domestic horses of the most different races and of all colours sometimes show such dark stripes; for example, a stripe along the back, a stripe across the shoulders, and the like. The sudden appearance of these stripes can only be explained by the supposition that it is the effect of a latent transmission, a relapse into the ancient original form, which has long since vanished, and was once common to all species of horses; the original form, undoubtedly, was originally striped like the zebras, quaggas, etc. In like manner, certain qualities in other domestic animals sometimes appear quite suddenly, which once marked their wild ancestors, now long since extinct. In plants, also, such a relapse can be observed very frequently. All my readers probably know the wild yellow toad-flax (*Linaria vulgaris*), a plant very common in our fields and hedges. Its dragon-mouthed yellow flower contains two long and two short stamens. But sometimes there appears a single blossom (*Peloria*) which is funnel-shaped, and quite regularly composed of five individual and equal sections, with five corresponding stamens. This *Peloria* can only be explained as a relapse into the long since extinct and very ancient common form of all those plants which, like the toad-flax, possess dragon-mouthed, two-lipped flowers, with two long and two short stamens. The original form, like the *Peloria*, possessed a regular five-spurred blossom, with five equal stamens, which only later and by degrees have become

unequal (compare p. 17). All such relapses are to be brought under the law of interrupted or latent transmission, although the number of intervening generations may be enormous.

When cultivated plants or domestic animals become wild, when they are withdrawn from the conditions of cultivated life, they experience changes which appear not only as adaptations to their new mode of life, but partially also as relapses into the ancient original form out of which the cultivated forms have been developed. Thus the different kinds of cabbage, which are exceedingly different in form, may be led back to the original form, by allowing them to grow wild. In like manner, dogs, horses, heifers, etc., when growing wild, often revert more or less to a long extinct generation. An immensely long succession of generations may pass away before this power of latent transmission becomes extinguished.

A third law of conservative transmission may be called the *law of sexual transmission*, according to which each sex transmits to the descendants of the same sex peculiarities which are not inherited by the descendants of the other sex. The so-called secondary sexual characters, which in many respects are of extraordinary interest, everywhere furnish numerous examples of this law. Subordinate or secondary sexual characters are those peculiarities of one of the two sexes which are not directly connected with the sexual organs themselves; such characters, which exclusively belong to the male sex, are, for example, the antlers of the stag, the mane of the lion, and the spur of the cock. The human beard, an ornament commonly denied to the female sex, belongs to the same class. Similar characteristics by which

the female sex is alone distinguished are, for example, the developed breasts, with the lactatory glands of female mammals and the pouch of the female opossum. The bodily size, also, and complexion, differs in female animals of many species from that of the male. All these secondary sexual qualities, like the sexual organs themselves, are transmitted by the male organism only to the male, not to the female, and *vice versâ*. Contrary facts are rare exceptions to the rule.

A fourth law of transmission, which has here to be mentioned, in a certain sense contradicts the last, and limits it, viz. the *law of mixed or mutual* (amphigonous) *transmission*. This law tells us that every organic individual produced in a sexual way receives qualities from both parents, from the father as well as from the mother. This fact, that personal qualities of each of the two sexes are transmitted to both male and female descendants, is very important. Goethe mentions it of himself, in the beautiful lines—

“Von Vater hab ich die Statur, des Lebens ernstes Führen
Von Mütterchen die Frohnatur und Lust zu fabuliren.”

“From my father I have my stature and the serious tenour of my life,
From my mother a joyous nature and a turn for poetizing.”

This phenomenon, I suppose, is so well-known to all, that I need not here enter upon it. It is according to the different portions of their character which father and mother transmit to their children, that the individual differences among brothers and sisters are chiefly determined.

The very important and interesting phenomenon of *hybridism* also belongs to this law of mixed or amphigonous

transmission. It alone, when rightly estimated, is quite sufficient to refute the prevailing dogma of the constancy of species. Plants, as well as animals, belonging to quite different species, may sexually mingle with one another and produce descendants which in many cases can again propagate themselves, and that indeed either (more frequently) by mingling with one of the two parental species, or (more rarely) by pure in-breeding, hybrid mixing with hybrid. The latter is well established, for example, in the hybrids of hares and rabbits (*Lepus Darwinii*, p. 147). The hybrids of a horse and a donkey, two different species of the same genus (*Equus*), are well known. These hybrids differ according as the father or the mother belongs to the one or the other species—the horse or the donkey. The mule produced by a mare and a he-donkey has qualities quite different from those of the jinny (*Hinnus*), the hybrid of a horse and she-donkey. In both cases the hybrid produced by the crossing of two different species is a mixed form, which receives qualities from both parents; but the qualities of the hybrid are different, according to the form of the crossing. In like manner, mulattoes produced by a European and a negress show a different mixture of characters from the hybrids produced by a negro with a European female. In these phenomena of hybrid-breeding, as well as in the other laws of transmission previously mentioned, we are as yet unable to show the acting causes in detail; but no naturalist doubts the fact that the causes are in all cases purely mechanical and dependent upon the nature of organic matter itself. If we possessed more delicate means of investigation than our rude organs of sense and auxilliary instruments, we should be able to

discover those causes, and to trace them to the chemical and physical properties of matter.

Among the phenomena of conservative transmission, we must now mention, as the fifth law, the *law of abridged or simplified transmission*. This law is very important in regard to embryology or ontogeny, that is in regard to the history of the development of organic individuals. *Ontogeny*, or the history of the development of individuals, as I have already mentioned in the first chapter (p. 10), and as I subsequently shall explain more minutely, is nothing but a short and quick repetition of *Phylogeny* dependent on the laws of transmission and adaptation—that is, a repetition of the palæontological history of development of the whole organic tribe, or phylum, to which the organism belongs. If, for example, we follow the individual development of a man, an ape, or any other higher mammal within the maternal body from the egg, we find that the foetus or embryo arising out of the egg passes through a series of very different forms, which on the whole agrees with, or at least runs parallel to, a series of forms which is presented to us by the historical chain of ancestors of the higher mammals. Among these ancestors we may mention certain fishes, amphibians, marsupials, etc. But the parallelism or agreement of these two series of development is never quite complete; on the contrary, in ontogeny there are always gaps and leaps which indicate the omission of certain stages belonging to the phylogeny. Fritz Müller, in his excellent work, “Für Darwin,”¹⁶ has clearly shown in the case of the Crustacea, or crabs, that “the historical record preserved in the individual history of development is gradually obscured, in proportion as development takes a more and more direct

route from the egg to the complete animal." This process of obscuring and shortening is determined by the law of abridged transmission, and I mention it here specially because it is of great importance for the understanding of embryology, and because it explains the fact, at first so strange, that the whole series of forms which our ancestors have passed through in their gradual development are no longer visible in the series of forms of our own individual development from the egg.

Opposed to the laws of the conservative transmission, hitherto discussed, are the phenomena of the transmission of the second series, that is, the *laws of progressive transmission by inheritance*. As already mentioned, they depend upon the fact that the organism transmits to its descendants not only those qualities which it has inherited from its own ancestors, but also a number of those individual qualities which it has acquired during its own lifetime. Adaptation is here seen to be connected with transmission by inheritance (Gen. Morph. ii. 186).

At the head of these important phenomena of progressive transmission, we may mention the *law of adapted or acquired transmission*. In reality it asserts nothing more than what I have said above, that in certain circumstances the organism is capable of transmitting to its descendants all the qualities which it has acquired during its own life by adaptation. This phenomenon, of course, shows itself most distinctly when the newly acquired peculiarity produces any considerable change in the inherited form. This is the case in the examples I mentioned in the preceding chapter as to transmission in general, in the case of the men with six fingers and toes, the porcupine men, copper beeches,

weeping willows, etc. The transmission of acquired diseases, such as consumption, madness, and albinism, likewise form very striking examples. Albinoes are those individuals who are distinguished by the absence of colouring matter, or pigments, in the skin. They are of frequent occurrence among men, animals, and plants. In the case of animals of a definite dark colour, individuals are not unfrequently born which are entirely without colour, and in animals possessing eyes, this absence of pigment extends even to the eyes, so that the iris of the eye, which is commonly of a bright or intense colour, is colourless, but appears red, on account of the blood-vessels being seen through it. Among many animals, such as rabbits and mice, albinoes with white fur and red eyes are so much liked that they are propagated in great numbers as a special race. This would be impossible were it not for the law of the transmission of adaptations.

Which of the changes acquired by an organism are transmitted to its descendants, and which are not, cannot be determined *à priori*, and we are unfortunately not acquainted with the definite conditions under which the transmission takes place. We only know in a general way that certain acquired qualities are much more easily transmitted than others, for example, more easily than the mutilations caused by accidents. These latter are generally not transmitted by inheritance, otherwise the descendants of men who have lost their arms or legs would be born without the corresponding arm or leg; but here, also, exceptions occur, and a race of dogs without tails has been produced by consistently cutting off the tails of both sexes of the dog during several generations. A few years ago a case occurred on an estate near Jena, in which by a careless slamming of

a stable door the tail of a bull was wrenched off, and the calves begotten by this bull were all born without a tail. This is certainly an exception; but it is very important to note the fact, that under certain unknown conditions such violent changes are transmitted in the same manner as many diseases.

In very many cases the change which is transmitted and preserved by adapted transmission is constitutional or in-born, as in the case of albinism mentioned before. The change then depends upon that form of adaptation which we call the indirect or potential. A very striking instance is furnished by the hornless cattle of Paraguay, in South America. A special race of oxen is there bred which is entirely without horns. It is descended from a single bull, which was born in 1770 of an ordinary pair of parents, and the absence of horns was the result of some unknown cause. All the descendants of this bull produced with a horned cow were entirely without horns. This quality was found advantageous, and by propagating the hornless cattle among one another, a hornless race was obtained, which at present has almost entirely supplanted the horned cattle in Paraguay. The case of the otter-sheep of North America forms a similar example. In the year 1791 a farmer, by name Seth Wright, lived in Massachusetts, in North America; in his normally formed flock of sheep a lamb was suddenly born with a surprisingly long body and very short and crooked legs. It was therefore unable to take any great leaps, and especially unable to leap across a hedge into a neighbour's garden—a quality which seemed advantageous to the owner, as the territories were divided by hedges. It therefore occurred to him to transmit this quality to other sheep, and by crossing

this ram with normally shaped ewes, he produced a whole race of sheep, all of which had the qualities of the father, short and crooked legs and a long body. None of them could leap across the hedges, and they therefore were much liked and propagated in Massachusetts.

A second law, which likewise belongs to the series of progressive transmissions, may be called the *law of established or habitual transmission*. It manifests itself in this, that qualities acquired by an organism during its individual life are the more certainly transmitted to its descendants the longer the causes of that change have been in action, and that this change becomes the more certainly the property of all subsequent generations the longer the cause of change acts upon these latter also. The quality newly acquired by adaptation or mutation must be established or constituted to a certain degree before we can calculate with any probability that it will be transmitted at all to the descendants. In this respect transmission resembles adaptation. The longer a newly acquired quality has been transmitted by inheritance, the more certainly will it be preserved in future generations. If, therefore, for example, a gardener by methodical treatment has produced a new kind of apple, he may calculate with the greater certainty upon preserving the desired peculiarity of this sort the longer he has transmitted the same by inheritance. The same is clearly shown in the transmission of diseases. The longer consumption or madness has been hereditary in a family the deeper is the root of the evil, and the more probable it is that all succeeding generations will suffer from it.

We may conclude the consideration of the phenomena of

inheritance with the two very important laws of *homotopic* and *contemporaneous transmission by inheritance*. We understand by them the fact that changes acquired by an organism during its life, and transmitted to its descendants, appear in the same part of the body in which the parental organism was first affected by them, and that they also appear in the offspring at the same age as that at which they did so in the parent.

The law of contemporaneous or homochronous transmission, which Darwin calls the law of "transmission in corresponding periods of life," can be shown very clearly in the transmission of diseases, especially of such as are recognized as very destructive, on account of their hereditary character. They generally appear in the organism of the child at the time corresponding with that in which the parental organism contracted the disease. Hereditary diseases of the lungs, liver, teeth, brain, skin, etc., usually appear in the descendants at the same period, or a little earlier than they showed themselves in the parental organism, or were contracted by it. The calf gets its horns at the same period of life as its parents did. In like manner the young stag receives its antlers at the same period of life in which they appeared in its father or grandfather. In every one of the different sorts of vine the grapes ripen at the same time as they did in the case of their progenitors. It is well known that the time of ripening varies greatly in the different sorts; but as all are descended from a single species, this variation has been acquired by the progenitors of the several sorts, and has then been transmitted by inheritance.

The *law of homotopic transmission*, which is most

closely connected with the last mentioned law, and which might be called the law of transmission in corresponding parts of the body, may also be very distinctly recognized in pathological cases of inheritance. Large moles, for example, or accumulations of pigment in several parts of the skin, tumours also, often appear during many generations, not only at the same period of life, but also in the same part of the skin. Excessive development of fat in certain parts of the body is likewise transmitted by inheritance. Above all, it is to be noted that numerous examples of this, as well as of the preceding law, may be found everywhere in the study of embryology. Both the *law of homochronous and homotopic transmission* are fundamental laws of embryology, or *ontogeny*. For these laws explain the remarkable fact that the different successive forms of individual development in all generations of one and the same species always appear in the same order of succession, and that the variations of the body always take place in the same parts. This apparently simple and self-evident phenomenon is nevertheless exceedingly wonderful and curious; we cannot explain its real causes, but may confidently assert that they are due to the direct transmission of the organic matter from the parental organism to that of the offspring, as we have seen above in the case of the process of transmission in general, by a consideration of the details of the various modes of reproduction.

Having thus, then, considered the most important laws of Inheritance, we now turn to the second series of phenomena bearing on natural selection, viz. to those of Adaptation or Variation. These phenomena, taken as a whole, stand in a certain opposition to the phenomena of Inheritance, and the difficulty which arises in examining them consists mainly

in the two sets of phenomena being so completely intercrossed and interwoven. We are but seldom able to say with certainty—of the variations of form which occur before our eyes—how much is owing to Inheritance, and how much to Adaptation. All characters of form, by which organisms are distinguished, are caused *either* by Inheritance or by Adaptation; but as both functions are continually interacting with each other, it is extremely difficult for the systematic inquirer to recognize the share belonging to each of the two functions in the special structure of individual forms. This is, at present, all the more difficult, because we are as yet scarcely aware of the immense importance of this fact, and because most naturalists have neglected the theory of Adaptation, as well as that of Inheritance. The laws of Inheritance, which we have just discussed, as well as the laws of Adaptation, which we shall consider directly, in reality form only a small portion of the phenomena existing in this domain, but which have not as yet been investigated; and since every one of these laws can interact with every other, it is clear that there is an infinite complication of physiological actions, which are at work in the construction of organisms.

But now, as to the phenomenon of variation or adaptation in general, we must, as in the case of inheritance, view it as a quite universal, physiological fundamental quality of all organisms, without exception—as a manifestation of life which cannot be separated from the idea of organism. Strictly speaking, we must here also, as in the case of inheritance, distinguish between Adaptation itself and Adaptability. By Adaptation (*Adaptio*), or Variation (*Variatio*), we understand the fact that the organism, in consequence of

influences of the surrounding outer world, assumes certain new peculiarities in its vital activity, composition, and form which it has not inherited from its parents; these acquired individual qualities are opposed to those which have been inherited, or, in other words, those which have been transmitted to it from its parents or ancestors. On the other hand, we call Adaptability (*Adaptabilitas*), or Variability (*Variabilitas*), the capability inherent in all organisms to acquire such new qualities under the influence of the outer world. (Gen. Morph. ii. 191.)

The undeniable fact of organic adaptation or variation is universally known, and can be observed at every moment in thousands of phenomena surrounding us. But just because the phenomena of variation by external influences appear so self-evident, they have hitherto undergone scarcely any accurate scientific investigation. To them belong all the phenomena which we look upon as the results of contracting and giving up habits, of practice and giving up practices, or as the results of training, of education, of acclimatization, of gymnastics, etc. Many permanent variations brought about by causes producing disease, that is to say, many diseases, are nothing but dangerous adaptations of the organism to injurious conditions of life. In the case of cultivated plants and domestic animals, variation is so striking and powerful that the breeder of animals and the gardener found their whole mode of proceeding upon it, or rather upon the interaction between these phenomena and those of Inheritance. It is also well known to every one that animals and plants, in their wild state, are subject to variation. Every systematic treatise on a group of animals or plants, if it were to be quite complete and exhaustive, ought to mention in every

individual species the number of variations which differ more or less from the prevailing or typical form of the species. Indeed, in every careful systematic special treatise one finds, in the case of most species, mention of a number of such variations, which are described sometimes as individual deviations, and sometimes as so-called races, varieties, degenerate species, or subordinate species, and which often differ exceedingly from the original species, solely in consequence of the adaptation of the organism to the external conditions of life.

If we now endeavour to fathom the general causes of these phenomena of Adaptation, we arrive at the conclusion that in reality they are as simple as the causes of the phenomena of Inheritance. We have shown that the nature of the process of propagation furnishes the real explanation of the facts of Transmission by Inheritance, that is, the transmission of parental matter to the body of the offspring; and in like manner we can show that the physiological function of *nutrition*, or *change of substance*, affords a general explanation of Adaptation or Variation. When I here point to "nutrition" as the fundamental cause of variation and adaptation, I take this word in its widest sense, and I understand by it the whole of the material changes which the organism undergoes in all its parts through the influences of the surrounding outer world. Nutrition thus comprises not only the reception of actual nutritive substances and the influence of different kinds of food, but also, for example, the action upon the organism of water and of the atmosphere, the influence of sunlight, of temperature, and of all those meteorological phenomena which are implied in the term "climate." The indirect and

direct influence of the nature of the soil and of the dwelling-place also belong to it; and further, the extremely important and varied influence which is exercised upon every animal and every plant by the surrounding organisms, friends and neighbours, enemies and robbers, parasites, etc. All these and many other very important influences, all of which more or less modify the organism in its material composition, must be taken into consideration in studying the change of substance which goes on in living things. Adaptation, accordingly, is the consequence of all those material variations which are produced in the change of substance of the organism by the external conditions of existence, or by the influences of the surrounding external world.

How very much every organism is dependent upon the whole of its external surroundings, and changed by their alteration, is, in a general way, well known to every one. Only think how much the human power of action is dependent upon the temperature of the air, or how much the disposition of our minds depends upon the colour of the sky. Accordingly as the sky is cloudless and sunny, or covered with large heavy clouds, our state of mind is cheerful or dull. How differently do we feel and think in a forest during a stormy winter night and during a bright summer day! All the different moods of our soul depend upon purely material changes of our brain, upon movements of molecular plasma, which are started through the medium of the senses by the different influences of light, warmth, moisture, etc. "We are a plaything to every pressure of the air." No less important and deeply influential are the effects produced upon our mind and body by the different quality and

quantity of food. Our mental activity, the activity of our understanding and of our imagination, is quite different accordingly as we have taken tea or coffee, wine or beer, before or during our work. Our moods, wishes, and feelings are quite different when we are hungry and when we are satisfied. The national character of Englishmen and Gauchos, in South America, who live principally on meat and food rich in nitrogen, is wholly different from that of the Irish, feeding on potatoes, and that of the Chinese, living on rice, both of whom take food deficient in nitrogen. The latter also form much more fat than the former. Here, as everywhere, the variations of the mind go hand in hand with the corresponding transformations of the body; both are produced by purely material causes. But all other organisms, in the same way as man, are varied and changed by the different influences of nutrition. It is well known that we can change in an arbitrary way the form, size, colour, etc., of our cultivated plants and domestic animals; by change of food; that, for example, we can take from or give to a plant definite qualities, accordingly as we expose it to a greater or less degree of sunlight and moisture. As these phenomena are generally widely known, and as we shall proceed presently to the consideration of the different laws of adaptation, we will not dwell here any longer on the general facts of variation.

As the different laws of transmission may be naturally divided into the two series of conservative and progressive transmission, so we may also distinguish between two series of the laws of adaptation, first, the series of laws of *indirect*, and secondly, the series of laws of *direct* adaptation. The latter may also be called the laws of actual, and the former the laws of potential, adaptation.

The first series, comprising the phenomena of *indirect* (potential) adaptation, has, on the whole, hitherto been little attended to, and Darwin has the merit of having directed special attention to this series of changes. It is somewhat difficult to place this subject clearly before the reader; I will endeavour to make it clear hereafter by examples. Speaking quite generally, indirect or potential adaptation consists in the fact that certain changes in the organism, effected by the influence of nutrition (in its widest sense) and of the external conditions of existence in general, show themselves not in the individual form of the respective organism, but in that of its descendants. Thus, especially in organisms propagating themselves in a sexual way, the reproductive system, or sexual apparatus, is often influenced by external causes (which little affect the rest of the organism), to such a degree that its descendants show a complete alteration of form. This can be seen very strikingly in artificially produced monstrosities. Monstrosities can be produced by subjecting the parental organism to certain extraordinary conditions of life, and, curiously enough, such an extraordinary condition of life does not produce a change of the organism itself, but a change in its descendants. This cannot be called transmission by inheritance, because it is not a quality existing in the parental organism that is transmitted by inheritance. It is, on the contrary, a change affecting the parental organism, but not perceptible in it, that appears in the peculiar formation of its descendants. It is only the impulse to this new formation which is transmitted in propagation through the egg of the mother or the sperm of the father. The new formation exists in the parental organism only as a possibility (potential); in the descendants it becomes a reality (actual).

As this very important and very general phenomenon had hitherto been entirely neglected, people were inclined to consider all the visible variations and transformations of organic forms as phenomena of adaptation of the second series, that is, as phenomena of *direct* or actual adaptation. The essence of this latter kind of adaptation consists in the fact that the change affecting the organism (through nutrition, etc.) shows itself immediately by some transformation, and does not only make itself apparent in the descendants. To this class belong all the well-known phenomena in which we can directly trace the transforming influence of climate, food, education, training, etc., in their effects upon the individual itself.

We have seen how the two series of phenomena of progressive and conservative transmission, in spite of their difference in principle, in many ways interfere with and modify each other, and in many ways co-operate with and cross each other. The same is the case, in a still higher degree, in the two series of phenomena of indirect and direct adaptation, which are opposed to each other and yet closely connected. Some naturalists, especially Darwin and Carl Vogt, ascribe to the indirect or potential adaptation by far the more important and almost exclusive influence. But the majority of naturalists have hitherto been inclined to take the opposite view, and to attribute the principal influence to direct or actual adaptation. I consider this controversy, in the mean while, as almost useless. It is but seldom that we are in a condition, in any individual case of variation, to judge how much of it belongs to direct and how much to indirect adaptation. We are, on the whole, still too little acquainted with these exceedingly important

and intricate relations, and can only assert, in a general way, that the transformation of organic forms is to be ascribed *either* to direct adaptation alone, *or* to indirect adaptation alone, or lastly, to the co-operation of both direct *and* indirect adaptation.

CHAPTER X.

LAWS OF ADAPTATION.

Laws of Indirect or Potential Adaptation.—Individual Adaptation.—Monstrous or Sudden Adaptation.—Sexual Adaptation.—Laws of Direct or Actual Adaptation.—Universal Adaptation.—Cumulative Adaptation.—Cumulative Influence of External Conditions of Existence and Cumulative Counter-Influence of the Organism.—Free Will.—Use and Non-use of Organs.—Practice and Habit.—Correlative Adaptation.—Correlation of Development.—Correlation of Organs.—Explanation of Indirect or Potential Adaptation by the Correlation of the Sexual Organs and of the other parts of the Body.—Divergent Adaptation.—Unlimited or Infinite Adaptation.

IN the last chapter we reduced into two groups the phenomena of Adaptation or Variation, which, in connection and interaction with the phenomena of Heredity, produce all the endless variety of forms in animals and plants—first, the group of indirect or potential, and secondly, the group of direct or actual Adaptation. We shall occupy ourselves with a closer examination of the different laws which we can discover in these two groups of the phenomena of variation. Let us first take into consideration the remarkable and very important, although hitherto much neglected, phenomena of indirect variation.

Indirect or potential adaptation manifests itself, it will be remembered, in the striking and exceedingly important fact

that organic individuals experience transformations and assume forms in consequence of changes of nutrition which have not operated on them themselves, but upon their parental organism. The transforming influence of the external conditions of existence, of climate, of nutrition, etc., shows its effects here not directly in the transformation of the organism itself, but indirectly in that of its descendants. (Gen. Morph. ii. 202.)

As the principal and most universal of the laws of indirect variation must be mentioned *the law of individual adaptation*, or the important proposition that all organic individuals from the commencement of their individual existence are unequal, although often very much alike. As a proof of this proposition, I may at once point to the fact, that in the human race in general all brothers and sisters, all children of the same parents, are unequal from their birth. No one will venture to assert that two children at their birth are perfectly alike: that the size of the individual parts of their bodies, the number of hairs on their heads, the number of cells composing their outer skins or epidermis, the number of blood-cells are the same in both children, or that both children have come into the world with the same abilities or talents. But what more specially proves this law of individual difference, is the fact that in the case of those animals which produce several young ones at a time,—for instance, dogs and cats,—all the young of each birth differ from one another more or less strikingly in size and colour of the individual parts of the body, or in strength, etc. Now this law is universal. All organic individuals from their beginning are distinguished by certain, though often extremely minute, differences, and the

cause of these individual differences, though in detail usually utterly unknown to us, depends partly or entirely on certain influences which the organs of propagation in the parental organism have undergone.

A second law of indirect adaptation, which we shall call *the law of monstrous or sudden adaptation*, is of less importance and less general than the law of individual adaptation. Here the divergences of the child-organism from the parental form are so striking that, as a rule, we may designate them as monstrosities. In many cases they are produced, as has been proved by experiments, by the parental organism having been subject to a certain treatment, and placed under peculiar conditions of nutrition ; for example, when air and light are withdrawn from it, or when other influences powerfully acting upon its nutrition are changed in a certain way. The new condition of existence causes a strong and striking modification of form, not directly of the organism itself, but only of that of its descendants. The mode of this influence in detail we cannot discover, and we can only in a very general way detect a causal connection between the abnormal formation of the child and a certain change in the conditions of existence of its parents exerting a special influence upon the organs of propagation in the latter. The previously mentioned phenomenon of albinism probably belongs to this group of abnormal or sudden variations, also the individual cases of human beings with six fingers and toes, the case of the hornless cattle, as well as those of sheep and goats with four or six horns. The abnormal deviation in all these cases probably owes its origin to a cause which at first only affected the reproductive system of the

parental organism, the egg of the mother or the sperm of the father.

A third curious manifestation of indirect adaptation may be termed *the law of sexual adaptation*. Under this name we indicate the remarkable fact that certain influences, which act upon the male organs of propagation only, affect the structure of the male descendants, and in like manner other influences, which act upon the female organs of propagation only, manifest their effect only in the change of structure of the female descendants. This remarkable phenomenon is still very obscure, and has not as yet been investigated, but is probably of great importance in regard to the origin of "secondary sexual characteristics," to which we have already made allusion.

All the phenomena of sexual, monstrous, and individual adaptation, which we may comprise under the name of the laws of *indirect or potential adaptation*, are as yet very little known to us in their real nature and in their deeper causal connection. Only this much we can at present maintain with certainty, that numerous and important transformations in organic forms owe their existence to this process. Many and striking variations of form solely depend on causes which at first only affect the nutrition of the parental organism, and specially its organs of propagation. Evidently the relations in which the sexual organs stand to other parts of the body are of the greatest importance. We shall have more to say of these presently, when we speak of the law of correlative adaptation. How powerfully the variations in the conditions of life and nutrition affect the propagation of organisms is rendered obvious by the remarkable fact that numerous wild animals which we keep

in our zoological gardens, and exotic plants which are grown in our botanical gardens, are no longer able to reproduce themselves. This is the case, for example, with most birds of prey, parrots, and monkeys. The elephant, also, and the animals of prey of the bear genus, in captivity hardly ever produce young ones. In like manner many plants in a cultivated state become sterile. The two sexes may indeed unite, but no fructification, or no development of the fructified germ, takes place. From this it follows with certainty that the changed mode of nutrition in the cultivated state is able completely to destroy the capability of reproduction, and therefore to exercise the greatest influence upon the sexual organs. In like manner other adaptations or variations of nutrition in the parental organism may cause, not indeed a complete want of descendants, but still important changes in their form.

Much better known than the phenomena of indirect or potential adaptation are those of *direct or actual adaptation*, to the consideration of which we now turn our attention. To them belong all those changes of organisms which are generally considered to be the results of practice, habit, training, education, etc.; also those changes of organic forms which are effected directly by the influence of nutrition, of climate, and other external conditions of existence. As has already been remarked in direct or actual adaptation, the transforming influence of the external cause affects the form of the organism itself, and does not only manifest itself in that of the descendants. (Gen. Morph. ii. 207.)

We may place *the law of universal adaptation* at the head of the different laws of direct or actual adaptation,

because it is the chief and most comprehensive among them. It may be briefly explained in the following proposition: "All organic individuals become unequal to one another in the course of their life by adaptation to different conditions of life, although the individuals of one and the same species remain mostly very much alike." A certain inequality of organic individuals, as we have seen, was already to be assumed in virtue of the law of individual (indirect) adaptation. But, beyond this, the original inequality of individuals is afterwards increased by the fact that every individual, during its own independent life, subjects and adapts itself to its own peculiar conditions of existence. All different individuals of every species, however like they may be in their first stages of life, become in the further course of their existence less like to one another. They deviate from one another in more or less important peculiarities, and this is a natural consequence of the different conditions under which the individuals live. There are no two single individuals of any species which can complete their life under exactly the same external circumstances. The vital conditions of nutrition, of moisture, air, light; further, the vital conditions of society, the inter-relations with surrounding individuals of the same or other species, are different in every individual being; and this difference first affects the functions, and later changes the form of every individual organism. If the children of a human family show, even at the beginning, certain individual inequalities which we may consider as the consequence of individual (indirect) adaptation, they will appear still more different at a later period of life, when each child has passed through different experiences, and has

adapted itself to different conditions of life. The original difference of the individual processes of development, evidently becomes greater the longer the life lasts and the more various the external conditions which influence the separate individuals. This may be demonstrated in the simplest manner in man, as well as in domestic animals and cultivated plants, in which the vital conditions may be arbitrarily modified. Two brothers, of whom one is brought up as a workman and the other as a priest, develop quite differently in body as well as in mind ; in like manner, two dogs of one and the same birth, of which one is trained as a sporting dog and the other chained up as a watch dog. The same observation may also readily be made as to organic individuals in a natural state. If, for instance, one carefully compares all the trees in a fir or beech forest, which consists of trees of a single species, one finds that among all the hundreds or thousands of trees, there are not two individual trees completely agreeing in size of trunk and other parts, in the number of branches, leaves, etc. Everywhere we find individual inequalities which, in part at least, are merely the consequences of the different conditions of life under which the trees have developed. It is true we can never say with certainty how much of this dissimilarity in all the individuals of every species may have originally been caused by indirect individual adaptation, and how much of it acquired under the influence of direct or universal adaptation.

A second series of phenomena of direct adaptation, which we may comprise under *the law of cumulative adaptation*, is no less important and general than universal adaptation. Under this name I include a great number of very important

phenomena, which are usually divided into two quite distinct groups. Naturalists, as a rule, have distinguished, first, those variations of organisms which are produced directly by the permanent influence of external conditions (by the constant action of nutrition, of climate, of surroundings, etc.), and secondly, those variations which arise from habit and practice, from accustoming themselves to definite conditions of life, and from the use and non-use of organs. The latter influences have been set forth especially by Lamarck as important causes of the change of organic forms, while the former have for a very long time been recognized as such more generally.

The sharp distinction usually made between these two groups of cumulative adaptation, and which even Darwin still maintains, disappears as soon as we reflect more accurately and deeply upon the real nature and causal foundation of these two, apparently very different, series of adaptations. We then arrive at the conviction that in both cases there are always two different active causes to be dealt with: on the one hand the *external influence* or *action* of adaptative conditions of life, and on the other hand the *internal reaction of the organism* which subjects and adapts itself to that condition of life. If cumulative adaptation is considered from the first point of view alone, and the transforming actions of the permanent external conditions of life are traced to those conditions solely, then the principal stress is laid unduly upon the external factor, and the necessary internal reaction of the organism is not taken into proper consideration. If, on the other hand, cumulative adaptation is unjustly regarded solely in relation to its second factor, and the transforming action of the organism

itself, its reaction against the external influences, its change by practice, habit, use, or non-use of organs, is put into the foreground, then we forget that this reaction is first called into play by the action of external conditions of existence. Hence it seems that the distinction made between these two groups lies only in the different manner of viewing them, and I believe that they can, with full justice, be considered as one. The most essential fact in these phenomena of cumulative adaptation is that the change of the organism which manifests itself first in the functions, and at a later period in the form, is the result either of long enduring, or of often repeated, influences of an external cause. The smallest cause, by cumulation of its action, can attain the greatest results.

There are innumerable examples of this kind of direct adaptation. In whatever direction we may examine the life of animals and plants, we discover on all hands evident and undeniable changes of this kind. Let me first mention some of those phenomena of adaptation occasioned directly by nutrition itself. Every one knows that the domestic animals which are bred for certain purposes can be variously modified, according to the different quantity and quality of the food given to them. If a farmer in breeding sheep wishes to produce fine wool, he gives them different food from what he would give if he wished to obtain good flesh or an abundance of fat. Choice race and carriage horses receive better food than dray and cart horses. Even the bodily form of man—for example, the amount of fat—is quite different according to his nutrition. Food containing much nitrogen produces little fat, that containing little nitrogen produces a great deal of fat.

People who, by means of Banting's system, at present so popular, wish to become thin eat only meat and eggs—no bread, no potatoes. The important variations that can be produced among cultivated plants, solely by changing the quantity and quality of nourishment, are well known. The same plant acquires an altogether different appearance, according as it is placed in a dry and warm place, exposed to the sunlight or placed in a cool damp spot in the shade. Many plants, if transferred to the sea shore, get in a short space of time thick, fleshy leaves, and the same plants placed in a particularly dry and hot locality get thin hairy leaves. All these variations arise directly from the cumulative influence of changed nutrition.

But it is not only the quantity and quality of the articles of nutrition which affect and powerfully change and transform the organism, but it is affected also by all the other external conditions of existence, above all by its nearest organic surroundings, the society of friendly or hostile organisms. One and the same kind of tree develops itself quite differently in an open locality, where it is free on all sides, and in a forest where it must adapt itself to its surroundings, where it is pressed on all sides by its nearest neighbours, and is forced to shoot upwards. In the former case, the branches of the tree spread widely out; in the latter, the trunk extends upwards, and the top of the tree remains small and contracted. How powerfully all these circumstances, and how powerfully the hostile or friendly influence of surrounding organisms, of parasites, etc., affect every animal and every plant, is so well known, that it appears superfluous to quote further examples. The change of form, or transformation which is thereby effected,

is never solely the direct result of the external influence, but must always be traced to the corresponding reaction, and to the activity of the organism itself, which consists in contracting a habit, or practice, and in the use or non-use of organs. The fact that these latter phenomena, as a rule, have been considered distinct from the former, is owing first to the one-sided manner of viewing them already mentioned, and secondly to the wrong notion which has been formed as to the nature and the influence of the activity of the will in animals.

The activity of the will, which is the organ of habit, of practice, of the use or non-use of organs among animals, is, like every other activity of the animal soul, dependent upon material processes in the central nervous system, upon peculiar motions which emanate from the albuminous matter of the ganglion cells, and the nervous fibres connected with them. The will, as well as the other mental activities, in higher animals, in this respect is different from that of men only in quantity, not in quality. The will of the animal, as well as that of man, is never free. The widely spread dogma of the freedom of the will is, from a scientific point of view, altogether untenable. Every physiologist who scientifically investigates the activity of the will in man and animals, must of necessity arrive at the conviction that *in reality the will is never free*, but is always determined by external or internal influences. These influences are for the most part ideas which have been either formed by Adaptation or by Inheritance, and are traceable to one or other of these two physiological functions. As soon as we strictly examine the action of our own will, without the traditional prejudice about its freedom, we

perceive that every apparently free action of the will is the result of previous ideas, which are based on notions inherited or otherwise acquired, and are therefore, in the end, dependent on the laws of Adaptation and Inheritance. The same also applies to the action of the will in all animals. As soon as their will is considered in connection with their mode of life, in its relation to the changes which the mode of life is subject to from external conditions, we are at once convinced that no other view is possible. Hence the changes of the will which follow the changes of nutrition, and which, in the form of practice, habit, etc., produce variations in structure, must be reckoned among the other material processes of cumulative adaptation.

Whilst an animal's will is adapting itself to changed conditions of existence by the acquisition of new habits, practices, etc., it not unfrequently effects the most remarkable transformations of the organic form. Numerous instances of this may be found everywhere in animal life. Thus, for example, many organs in domestic animals are suppressed, when in consequence of a changed mode of life they cease to act. Ducks and fowls in a wild state fly exceedingly well, but lose this facility more or less in a cultivated state. They accustom themselves to use their legs more than their wings, and in consequence the muscles and skeleton used in flying are essentially changed in their development and form. Darwin has proved this by a very careful comparative measurement and weighing of the respective parts of the skeleton in the different races of domestic ducks, which are all descended from the wild duck (*Anas boschas*). The bones of the wings in tame ducks are weaker, the bones of the legs, on the other hand, are more

strongly developed than in wild ducks. In ostriches and other running birds which have become completely unaccustomed to fly, the consequence is that their wings are entirely crippled and degenerate into mere "rudimentary organs" (p. 12). In many domestic animals, especially in many races of dogs and rabbits, we find that in the cultivated state they have acquired pendulous ears. This is simply a consequence of a diminished use of the auricular muscles. In a wild state these animals have to exert their ears very much in order to discover an approaching foe, and this is accompanied by a strong development of the muscular apparatus, which keeps the outer ears in an upright position, and by which they can turn them in all directions. In a domestic state the same animals no longer require to listen so attentively, they prick up or turn their ears only a little; the auricular muscles cease to be used, gradually become weakened, and the ears hang down flabbily, or become rudimentary.

As in these cases the function, and consequently the form also, of the organ becomes degenerated through disuse, so, on the other hand, it becomes more developed by greater use. This is particularly striking if we compare the brain, and the mental activity belonging to it, in wild animals and those domestic animals which are descended from them. The dog and horse, which are so vastly improved by cultivation, show an extraordinary degree of mental development, in comparison with their wild original ancestors, and evidently the change in the bulk of the brain, which is connected with it, is mainly determined by persistent exercise. It is also well known how quickly and powerfully muscles grow and change their form by con-

tinual practice. Compare, for example, the arms and legs of a trained gymnast with those of an immovable book-worm.

How powerfully external influences affect the habits of animals and their mode of life, and in this way still further change their forms, is very strikingly shown in many cases among amphibious animals and reptiles. Our commonest indigenous snake, the ringed snake, lays eggs which require three weeks' time to develop. But when it is kept in captivity, and no sand is strewn in the cage, it does not lay its eggs, but retains them until the young ones are developed. The difference between animals producing living offspring and those laying eggs is here effaced simply by the change of the ground upon which the animal lives.

The water-salamanders, or tritons, which have been artificially made to retain their original gills, are extremely interesting in this respect. The tritons are amphibious animals, nearly akin to frogs, and possess, like the latter, in their youth external organs of respiration—gills—with which they, while living in water, breathe the air dissolved in the water. At a later date a metamorphosis takes place in tritons, as in frogs. They leave the water, lose their gills, and accustom themselves to breathe with their lungs. But if they are prevented from doing this by being kept shut up in a tank, they do not lose their gills. The gills remain, and the water salamander continues through life in that low stage of development, beyond which its lower relations, the gilled salamanders, or *Sozobranchiata*, never pass. The gilled salamander attains its full size, its sexual development, and reproduces itself without losing its gills.

Great interest was caused a short time ago, among

zoologists, by the axolotel (*Siredon pisciformis*), a gilled salamander from Mexico, nearly related to the triton; it had already been known for a long time, and been bred on a large scale in the zoological garden in Paris. This animal possesses external gills, like the young salamander, but retains them all its life, like all other Sozobranchiata. This gilled salamander generally remains in the water, with its aquatic organs of respiration, and also propagates itself there. But in the Paris garden, unexpectedly from among hundreds of these animals, a small number crept out of the water on to the dry land, lost their gills, and changed themselves into gill-less salamanders, which are not to be distinguished from a North-American genus of tritons (*Amblystoma*), and breathe only through lungs. In this exceedingly curious case we can directly follow the great stride from water-breathing to air-breathing animals, a stride which can indeed be observed every spring in the individual history of development of frogs and salamanders. Just as every separate frog and every separate salamander transforms itself from an amphibious animal breathing through gills, at a later period into one breathing through lungs, so the whole group of frogs and salamanders have arisen from animals breathing through gills, and akin to the *Siredon*. The Sozobranchiata have remained up to the present day in that low stage of development. Ontogeny here explains phylogeny; the history of the development of individuals explains that of the whole group (p. 10).

To the law of accumulative adaptation there closely follows a third law of direct or actual adaptation, *the law of correlative adaptation*. According to this important law, actual adaptation not only changes those parts of the

organism which are directly affected by its influence, but other parts also not directly affected by it. This is the consequence of organic solidarity, and especially of the unity of the nutrition existing among all the parts of every organism. If, for example, the hairiness of the leaves increases in a plant by its being transferred to a dry locality, then this change reacts upon the nutrition of other parts, and it may result in a shortening of the parts of the stalk; and produce a more contracted form of the whole plant. In some races of pigs and dogs—for example, in the Turkish dog—which by adaptation to a warmer climate have more or less lost their hair, the teeth also have degenerated. Whales and Endentata (armadillos), which by their curious skin-covering are removed from the other mammals, also show the greatest deviations in the formation of their teeth. Further, those races of domestic animals (oxen and pigs) which have acquired short legs have, as a rule, also a short and compact head. Among other examples, the races of pigeons which have the longest legs are also characterized by the longest beaks. The same correlation between the length of the legs and beaks is universal in the order of stilted-birds (Grallatores), in storks, cranes, snipe, etc. The correlations which thus exist between different parts of the organism are most remarkable, but their real cause is unknown to us. In general, we can of course say, the changes of nutrition affecting an individual part must necessarily react on the other parts, because the nutrition of every organism is a connected, centralized activity. But why just this or that part should exhibit this or that particular correlation is in most cases quite unknown to us. We know a great number of such correlations in nutrition; they are especially seen in

those changes of animals and plants which give rise to an absence of pigment (noticed previously)—in albinos. The want of the usual colouring matter goes hand in hand with certain changes in the formation of other parts; for example, of the muscular and osseous system, consequently of organic systems which are not at all ultimately connected with the system of the outer skin. Very frequently albinos are more feebly developed, and consequently the whole structure of the body is more delicate and weak than in coloured animals of the same species. The organs of the senses and nervous system are in like manner curiously affected when there is this want of pigment. White cats with blue eyes are nearly always deaf. White horses are distinguished from coloured horses by their special liability to form sarkomatous tumours. In man, also, the degree of the development of pigment in the outer skin greatly influences the susceptibility of the organism for certain diseases; so that, for instance, Europeans with a dark complexion, black hair, and brown eyes become more easily acclimatized to tropical countries, and are less subject to the diseases there prevalent (inflammation of the liver, yellow fever, etc.) than Europeans of white complexion, fair hair, and blue eyes. (Compare above, p. 150.)

Among these correlations in the formation of different organs, those are specially remarkable which exist between the sexual organs and other parts of the body. No change of any part reacts so powerfully upon the other parts of the body as a certain treatment of the sexual organs. Farmers who wish to obtain an abundant formation of fat in pigs, sheep, etc., remove the sexual organs by cutting them out (castration), and this is indeed done to animals of both sexes,

The result is an excessive development of fat. The same is done to the singers in certain religious corporations. These unfortunates are castrated in early youth, in order that they may retain their high boyish voices. In consequence of this mutilation of the genitals, the larynx remains in its youthful stage of development. The muscular tissues of the body remain at the same time weakly developed, while below the skin an abundance of fat accumulates. But this mutilation also powerfully reacts upon the development of the nervous system, the energy of the will, etc., and it is well known that human castrates, or eunuchs, as well as castrated animals, are utterly deficient in the special psychical character which distinguishes the male sex. Man is a man, both in body and soul, solely through his male generative glands.

These most important and influential correlations between the sexual organs and the other parts of the body, especially the brain, are found equally in both sexes. This might be expected even *à priori*, because in most animals the two kinds of organs develop themselves from the same foundation, and at the beginning are not different. In man, as in the rest of the vertebrate animals, the male and female organs in the original state of the germ are entirely the same, and the differences of the two sexes only gradually arise in the course of embryonic development (in man, in the ninth week of embryonic life), by one and the same gland developing in the female as the ovary, and in the male as the testicle. Every change of the female ovary, therefore, has a no less important reaction upon the whole female organism than every change of the testicle has upon the male organism. Virchow has expressed the importance of this correlation in his admirable essay on "Das Weib und die

Zelle" ("Woman and the Cell"), in the following words:—"Woman is woman only by her sexual glands; all the peculiarities of her body and mind, of her nutrition and her nervous activity, the sweet delicacy and roundness of her limbs, the peculiar formation of the pelvis, the development of the breasts, the continuance of the high voice, that beautiful ornament of hair on her head, with the scarcely perceptible soft down on the rest of the skin—then again, the depth of feeling, the truth of her direct perceptions, her gentleness, devotion, and fidelity—in short, all the feminine qualities which we admire and honour in a true woman are but a dependence of the ovary. Take this ovary away, and the man-woman stands before us—a loathly abortion."

The same close correlation between the sexual organs and the other parts of the body occurs among plants as generally as among animals. If one wishes to obtain an abundance of fruit from a garden plant, the growth of the leaves is curtailed by cutting off some of them. If, on the other hand, an ornamental plant with a luxuriance of large and beautiful leaves is desired, then the development of the blossoms and fruit is prevented by cutting off the flower buds. In both cases one system of organs develops at the cost of the others. Thus, also, most variations in the formation of leaves in wild plants result in corresponding transformations of the generative parts or blossoms. The great importance of this "compensation of development," of this "correlation of parts," has been already set forth by Goethe, by Geoffroy St. Hilaire, and other nature-philosophers. It rests mainly upon the fact that direct or actual adaptation cannot produce an important change in a single part of the body, without at the same time affecting the whole organism.

The correlative adaptation between the reproductive organs and the other parts of the body deserves a very special consideration, because it is, above all others, likely to throw light upon the obscure and mysterious phenomena of indirect or potential adaptation, which have already been considered. For just as every change of the sexual organs powerfully reacts upon the rest of the body, so on the other hand every important change in another part of the body must necessarily more or less react on the sexual organs. This reaction, however, will only become perceptible in the formation of the offspring which arise out of the changed generative parts. It is, in fact, precisely those remarkable and imperceptible changes of the genital system (in themselves utterly insignificant changes)—changes of the eggs and the sperm—brought about by such correlations, which have the greatest influence upon the formation of the offspring, and all the phenomena of indirect or potential adaptation previously mentioned may in the end be traced to correlative adaptation.

A further series of remarkable examples of correlative adaptation is furnished by the different animals and plants which become degenerated through parasitic life or parasitism. No other change in the mode of life so much affects the shapes of organisms as the adoption of a parasitical life. Plants thereby lose their green leaves; as, for instance, our native parasitical plants, *Orobanche*, *Lathræa*, *Monotropa*. Animals which originally have lived freely and independently, but afterwards adopt a parasitical mode of life on other animals or plants, in the first place cease to use their organs of motion and their organs of sense. The loss of this activity is succeeded by the loss of

the organs themselves, and thus we find, for example, many crabs, or crustacea, which in their youth possess a tolerably high degree of organization, viz. legs, antennæ, and eyes, in old age completely degenerate, living as parasites, without eyes, without apparatus of motion, and without antennæ. The lively, active form of youth, has become a shapeless, motionless lump. Only the most necessary organs of nutrition and propagation retain their activity; all the rest of the body has degenerated. Evidently these complete transformations are, to a large extent, the direct consequences of cumulative adaption, of the non-use and defective exercise of the organs, but a great portion of them must certainly be attributed also to correlative adaptation. (Compare Plate X. and XI.).

A seventh law of adaptation, the fourth in the group of direct adaptation, is *the law of divergent adaptation*. By this law we indicate the fact that parts originally formed alike have developed in different ways under the influence of external conditions. This law of adaptation is extremely important for the explanation of the phenomenon of division of labour, or polymorphism. We can see this very easily in our own selves; for instance, in the activity of our two hands. We usually accustom our right hand to quite different work from that which we give our left, and in consequence of the different occupation there arises a different formation of the two hands. The right hand, which we use much more than the left, shows a stronger development of the nerves, muscles, and bones. The same applies to the whole arm. In most human beings the bones and flesh of the right arm are, in consequence of their being more employed, stronger and heavier than

those of the left arm. Now, as the special use of the right arm has been adopted and transmitted by inheritance for thousands of years among Europeans, the stronger shape and size of the right arm have already become hereditary. P. Harting, an excellent Dutch naturalist, has shown by measuring and weighing newly-born children, that even in them the right arm is more developed than the left.

According to the same law of divergent adaptation, both eyes also frequently develop differently. If, for example, a naturalist accustoms himself always to use one eye for the microscope (it is better to use the left), then that eye will acquire a power different from that of the other, and this division of labour is of great advantage. The one eye will become more short-sighted, and better suited for seeing things near at hand ; the other eye becomes, on the contrary, more long-sighted, more acute for looking at an object in the distance. If, on the other hand, the naturalist alternately uses both eyes for the microscope, he will not acquire the short-sightedness of the one eye and the compensatory degree of long-sight in the other, which is attained by a wise distribution of these different functions of sight between the two eyes. Here then again the function, that is the activity, of originally equally-formed organs can become divergent by habit ; the function reacts again upon the form of the organ, and thus we find, after a long duration of such an influence, a change in the more delicate parts and the relative growth of the divergent organs, which in the end becomes apparent even in their coarser outlines.

Divergent adaptation can very easily be perceived among plants, especially in creepers. Branches of one and the same creeping plant, which originally were formed alike,

acquire a completely different form and extent, a completely different degree of curvature and diameter of spiral winding, according as they twine themselves round a thinner or a thicker bar. The divergent change of form of parts originally identical in form, which tending in different directions develop themselves under different external conditions, can be distinctly demonstrated in many other examples. As this divergent adaptation interacts with progressive inheritance, it becomes the cause of a division of labour among the different organs.

An eighth and last law of adaptation we may call *the law of unlimited or infinite adaptation*. By it we simply mean to express that we know of no limit to the variation of organic forms occasioned by the external conditions of existence. We can assert of no single part of an organism, that it is no longer variable, or that if it were subjected to new external conditions it would not be changed by them. It has never yet been proved by experience that there is a limit to variation. If, for example, an organ degenerates from non-use, this degeneration ends finally in a complete disappearance of the organ, as is the case with the eyes of many animals. On the other hand, we are able, by continual practice, habit, and the ever-increasing use of an organ, to bring it to a degree of perfection which we should at the beginning have considered to be impossible. If we compare the uncivilized savages with civilized nations, we find among the former a development of the organs of sense—sight, smell, and hearing—such as civilized nations can hardly conceive of. On the other hand, the brain, that is mental activity, among more civilized nations is developed to a degree of which the wild savages have no idea.

There appears indeed to be a limit given to the adaptability of every organism, by the "type" of its tribe or phylum; that is, by the essential fundamental qualities of this tribe, which have been inherited from a common ancestor, and transmitted by conservative inheritance to all its descendants. Thus, for example, no vertebrate animal can acquire the ventral nerve-chord of articulate animals, instead of the characteristic spinal marrow of the vertebrate animals. However, within this hereditary primary form, within this inalienable type, the degree of adaptability is unlimited. The elasticity and fluidity of the organic form manifests itself, within the type, freely in all directions, and to an unlimited extent. But there are some animals, as, for example, the parasitically degenerate crabs and worms, which seem to pass even the limit of type, and have forfeited all the essential characteristics of their tribe by an astonishing degree of degeneration. As to the adaptability of man, it is, as in all other animals, also unlimited, and since it is manifested in him above all other animals, in the modifications of the brain, there can be absolutely no limit to the knowledge which man in a further progress of mental cultivation may not be able to exceed. The human mind, according to the law of unlimited adaptation, enjoys an infinite perspective of becoming ever more and more perfect.

These remarks are sufficient to show the extent of the phenomena of Adaptation, and the great importance to be attached to them. The laws of Adaptation; or the facts of Variation caused by the influence of external conditions, are just as important as the laws of Inheritance. All phenomena of Adaptation, in the end, can be traced to

conditions of nutrition of the organism, in the same way as the phenomena of Inheritance are referable to conditions of reproduction; but the latter, as well as the former, may further be traced to chemical and physical, that is to mechanical, causes. According to Darwin's Theory of Selection the new forms of organisms, the transformations which artificial selection produces in the state of cultivation, and which natural selection produces in the state of nature, arise solely by the interaction of such causes.

CHAPTER XI.

NATURAL SELECTION BY THE STRUGGLE FOR EXISTENCE. DIVISION OF LABOUR AND PROGRESS.

Interaction of the Two Organic Formative Causes, Inheritance and Adaptation.—Natural and Artificial Selection.—Struggle for Existence, or Competition for the Necessaries of Life.—Disproportion between the Number of Possible or Potential, and the Number of Real or Actual Individuals.—Complicated Correlations of all Neighbouring Organisms.—Mode of Action in Natural Selection.—Homochromic Selection as the Cause of Sympathetic Colourings.—Sexual Selection as the Cause of the Secondary Sexual Characters.—Law of Separation or Division of Labour (Polymorphism, Differentiation, Divergence of Characters).—Transition of Varieties into Species.—Idea of Species.—Hybridism.—Law of Progress or Perfectioning (Progressus, Teleosis).

IN order to arrive at a right understanding of Darwinism, it is, above all, necessary that the two organic functions of *Inheritance and Adaptation*, which we spoke of in our last chapter, should be more closely examined. If we do not, on the one hand, examine the purely mechanical nature of these two physiological activities, and the various action of their different laws, and if, on the other hand, we do not consider how complicated the interaction of these different laws of Inheritance and Adaptation must be, we shall not be able to understand how these two functions, by themselves, have been able to produce all the variety of

animal and vegetable forms, which, in fact, they have. We have, at least, hitherto been unable to discover any other formative causes besides these two, and if we rightly understand the necessary and infinitely complicated interaction of Inheritance and Adaptation, we do not require to look for other unknown causes for the change of organic forms. These two fundamental causes are, as far as we can see, completely sufficient.

Even long before Darwin had published his Theory of Selection, some naturalists, and especially Goethe, had assumed the interaction of two distinct formative tendencies—a conservative or preserving, and a progressive or changing formative tendency—as the causes of the variety of organic forms. The former was called by Goethe the centripetal or specifying tendency, the latter the centrifugal tendency, or the tendency to metamorphosis (p. 89). These two tendencies completely correspond with the two processes of Inheritance and Adaptation. *Inheritance* is the *centripetal* or *internal formative tendency* which strives to keep the organic form in its species, to form the descendants like the parents, and always to produce identical things from generation to generation. *Adaptation*, on the other hand, which counteracts inheritance, is the *centrifugal* or *external formative tendency*, which constantly strives to change the organic forms through the influence of the varying agencies of the outer world, to create new forms out of those existing, and entirely to destroy the constancy or permanency of species. Accordingly as Inheritance or Adaptation predominates in the struggle, the specific form either remains constant or changes into a new species. The degree of constancy of form in the different species of animals and

plants, which obtains at any moment, is simply the necessary result of the momentary predominance which either of these two formative powers (or physiological activities) has acquired over the other.

If we now return to the consideration of the process of selection or choice, the outlines of which we have already examined, we shall be in a position to see clearly and distinctly that both artificial and natural selection rest solely upon the interaction of these two formative tendencies. If we carefully watch the proceedings of an artificial selector—a farmer or a gardener—we find that only these two constructive forces are used by him for the production of new forms. The whole art of artificial selection rests solely upon a thoughtful and wise application of the laws of Inheritance and Adaptation, and upon their being applied and regulated in an artistic and systematic manner. Here the will of man constitutes the selecting force.

The case of natural selection is quite similar, for it also employs merely these two organic constructive forces, these ingrained physiological properties of Adaptation and Heredity, in order to produce the different species. But the selecting principle or force, which in *artificial* selection is represented by the conscious *will of man* acting for a definite purpose, consists in *natural* selection of the unconscious *struggle for existence* acting without a definite plan. What we mean by “struggle for existence” has already been explained in the seventh chapter. It is the recognition of this exceedingly important identity which constitutes one of the greatest of Darwin’s merits. But as this relation is very frequently imperfectly or falsely understood, it is necessary to examine it now more closely, and to illustrate

by a few examples the operation of the struggle for life, and the operation of natural selection *by means of* the struggle for life (Gen. Morph. ii. 231).

When considering the struggle for life, we started from the fact that the number of germs which all animals and plants produce is infinitely greater than the number of individuals which actually come to life and remain alive for a longer or shorter time. Most organisms produce during life thousands or millions of germs, from each of which, under favourable circumstances, a new individual might arise. In most animals and plants these germs are eggs, that is cells, which for their development require sexual fructification. But among the Protista, the lowest organisms, which are neither animals nor plants, and which propagate themselves only in a non-sexual manner, the germ-cells, or spores, require no fructification. Now, in all cases the number of unsexual, as well as of sexual germs, is out of all proportion to the number of actually living individuals of every species.

Taken as a whole, the number of living animals and plants on our earth remains always about the same. The number of places in the economy of nature is limited, and in most parts of the earth's surface these places are always approximately occupied. Certainly there occur everywhere and in every year fluctuations in the absolute and in the relative number of individuals of all species. However, taken as a whole, these fluctuations are of little importance, and it is broadly the fact that the total number of all individuals remains, on an average, almost constant. There is a constant fluctuation, which depends on the fact that in one year or another one or other series of animals and plants

predominates, and that every year the struggle for life somewhat alters their relations.

Every single species of animals and plants would have densely peopled the whole earth's surface in a short time, if it had not had to struggle against a number of enemies and hostile influences. Even Linnæus calculated that if an annual plant only produced two seeds (and there is not one which produces so few), it would have yielded in twenty years a million of individuals. Darwin has calculated of elephants, which of all animals seem the slowest to increase, that in seven hundred and fifty years the descendants of a single pair would amount to nineteen millions of individuals; this is supposing that every elephant, during its period of fertility (from the 30th to the 90th year), produced only three pairs of young ones, and survived itself to its hundredth year. In like manner the increase of the number of human beings—if calculated on the average proportion of births to population, and no hindrances to the natural increase stood in the way—would be such as to double the total in twenty-five years. In every century the total number of men would have increased sixteen-fold; whereas we know that the total number of human beings increases but slowly, and that the increase of population is very different in different countries. While European tribes spread over the whole globe, other tribes or species of men every year draw nearer to their complete extinction. This is the case especially with the redskins of America, and with the copper-coloured natives of Australia. Even if these races were to propagate more abundantly than the white Europeans, yet they would sooner or later succumb to the latter in the struggle for life. But of all human

individuals, as of all other organisms, by far the majority perish at the earliest period of their lives. Of the immense quantity of germs which every species produce, only very few actually succeed in developing, and of these few it is again only a very small portion which attain to the age in which they can reproduce themselves (compare p. 161).

From the disproportion between the immense excess of organic germs and the small number of chosen individuals which are actually able to continue in existence beside one another, there follows of necessity that universal struggle for life, that constant fight for existence, that perpetual competition for the necessities of life, of which I gave a sketch in my seventh chapter. It is this struggle for life which brings natural selection into play, which in its turn is made use of by the interaction of the phenomena of Inheritance and Adaptation as a sifting agency, and which thus causes a continual change in all organic forms. In this struggle for acquiring the necessary conditions of existence, those individuals will always overpower their rivals who possess any individual privilege, any advantageous quality, of which their fellow competitors are destitute. It is true we are able only in the fewest cases (in those animals and plants best known to us) to form an approximate conception of the infinitely complicated interaction of the numerous circumstances, all of which here come into combination. Only think how infinitely varied and complicated are the relations of every single human being to the rest of mankind, and in general, to the whole of the surrounding outer world. But similar relations prevail also among all animals and plants which live together in one place. All influence one another

actively or passively. Every animal and every plant struggles directly with a number of enemies, beasts of prey, parasitic animals, etc. Plants standing together struggle with one another for the space of ground requisite for their roots, for the necessary amount of light, air, moisture, etc. In like-manner, animals living together struggle with one another for their food, dwelling-place, etc. In this most active and complicated struggle, any personal superiority, however small, any individual advantage, may possibly decide the issue in favour of the one possessing it. This privileged individual remains the victor in the struggle, and propagates itself, while its fellow-competitors perish before they succeed in propagating themselves. The personal advantage which gave it the victory is transmitted by inheritance to its descendants, and by a further development may become so strongly marked as to cause us to consider the later generations as a new species.

The infinitely complicated correlations which exist between the organisms of every district, and which must be looked upon as the real conditions of the struggle for life, are mostly unknown to us, and are very difficult to discover. We have hitherto been able to trace them only to a certain point in individual cases, as in the example given by Darwin of the relations between cats and red clover in England. The red clover (*Trifolium pratense*), which in England is among the best fodder for cattle, requires the visit of humming-bees in order to attain the formation of seeds. These insects, while sucking the honey from the bottom of the flower, bring the pollen in contact with the stigma, and thus cause the fructification of the flower, which never takes place without it. Darwin has

shown by experiments, that red clover which is not visited by humming-bees does not yield a single seed. The number of bees is determined by the number of their enemies, the most destructive of which are the field-mice. The more the field-mice predominate, the less the clover is fructified. The number of field-mice, again, is dependent upon the number of their enemies, principally cats. Hence in the neighbourhood of villages and towns, where many cats are kept, there are plenty of bees. A great number of cats, therefore, is evidently of great advantage for the fructification of clover. This example may be followed still further, as has been done by Carl Vogt, if we consider that cattle which feed on red clover are one of the most important foundations of the wealth of England. Englishmen preserve their bodily and mental powers chiefly by making excellent meat—roast beef and beefsteak—their principal food. The English owe the superiority of their brains and minds over those of other nations in a great measure to their excellent meat. But this is clearly indirectly dependent upon the cats, which pursue the mice. We may, with Huxley, even trace the chain of causes to those old maids who cherish and keep cats, and, consequently, are of the greatest importance to the fructification of the clover and to the prosperity of England. From this example we can see that the further it is traced the wider is the circle of action and of correlation. We can with certainty maintain that there exist a great number of such correlations in every plant and in every animal, only we are not always able to point out and survey their concatenation as in the last instance.

Another remarkable example of important correlations is the following, given by Darwin. In Paraguay, there are

no wild oxen and horses, as in the neighbouring parts of South America, both north and south of Paraguay. This surprising circumstance is explained simply by the fact that in that country a kind of small fly is very frequent, and is in the habit of laying its eggs in the navel of newly-born calves and foals. The newly-born animals die in consequence of this attack, and the small deadly fly is therefore the cause of oxen and horses never becoming wild in that district. Supposing that this fly were destroyed by some insect-eating bird, then these large mammals would grow wild in Paraguay, as well as in the neighbouring parts of South America; and as they would eat a quantity of certain species of plants, the whole flora, and, consequently again, the whole fauna of the country would become changed. It is hardly necessary to state, that at the same time the whole economy, and consequently the character, of the human population would alter.

Thus the prosperity, nay, even the existence of whole populations can be indirectly determined by a single small animal or vegetable form in itself extremely insignificant. There are small coral islands whose human inhabitants live almost entirely upon the fruit of a species of palm. The fructification of this palm is principally effected by insects, which carry the pollen from the male to the female palm trees. The existence of these useful insects is endangered by insect-eating birds, which in their turn are pursued by birds of prey. The birds of prey, however, often succumb to the attack of a small parasitical mite, which develops itself in millions in their feathers. This small, dangerous parasite, again, may be killed by parasitical moulds. Moulds, birds of prey, and insects would in this case favour the prosperity

of the palm, and consequently of man; birds, mites, and insect-eating birds would, on the other hand, endanger it.

Interesting examples in relation to the change of correlations in the struggle for life are furnished also by those isolated oceanic islands, uninhabited by man, on which at different times goats and pigs have been placed by navigators. These animals become wild, and having no enemies, they increase in number so excessively, that the rest of the animal and vegetable population suffer in consequence, and the island finally may become almost a waste, because there is insufficient food for the large mammals which increase too numerously. In some cases on an island thus overrun with goats and pigs, other navigators have let loose a couple of dogs, who enjoyed this superabundance of food, and they again increased so numerously, and made such havoc among the herds, that after several years the dogs themselves lacked food, and they also almost died out. The equilibrium of species continually changes in this manner in nature's economy, accordingly as one or another species increases at the expense of the rest. In most cases the relations of different species of animals and plants to one another are much too complicated for us to be able to follow them, and I leave it to the reader to picture to himself what an infinitely complicated machinery is at work in every part of the world in consequence of this struggle. The impulses which started the struggle, and which altered and modified it in different places, are in the end seen to be the impulses of self-preservation—in fact, the instinct leading individuals to preserve themselves (the instinct of obtaining food), and the instinct leading them to preserve the species (instinct of propagation). It is these two fundamental instincts of

organic self-preservation of which Schiller, the idealist (not Goethe, the realist !) says :

“ Meanwhile, until philosophy
Sustains the structure of the world,
Her workings will be carried on
By hunger and by love.”*

It is these two powerful fundamental instincts which, by their varying activity, produce such extraordinary differences in species through the struggle for life. They are the foundations of the phenomena of Inheritance and Adaptation. We have, in fact, traced all phenomena of Inheritance to propagation, all phenomena of Adaptation to nutrition, as the two wider classes of material phenomena to which they belong.

The struggle for life in natural selection acts with as much selective power as does the will of man in artificial selection. The latter, however, acts according to a plan and consciously, the former without a plan and unconsciously. This important difference between artificial and natural selection deserves especial consideration. For we learn by it to understand how *arrangements serving a purpose can be produced by mechanical causes acting without an object, as well as by causes acting for an object*. The products of natural selection are arranged even more for a purpose than the artificial products of man, and yet they owe their existence not to a creative power acting for a definite purpose, but to a mechanical relation acting uncon-

* “ Einstweilen bis den Bau der Welt
Philosophie zusammenhält,
Erhält sich ihr Getriebe
Durch Hunger und durch Liebe.

sciously and without a plan. If we had not thoroughly considered the interaction of Inheritance and Adaptation under the influence of the struggle for life, we should not at first be inclined to expect such results from this natural process of selection as are, in fact, furnished by it. It may therefore be appropriate here to mention a few especially striking examples of the activity of natural selection.

Let us first take *Darwin's homochromic selection* of animals, or the so-called "sympathetic selection of colours," into consideration. Earlier naturalists have remarked that numerous animals are of nearly the same colour as their dwelling-place, or the surroundings in which they permanently live. Thus, for example, plant-lice and many other insects living on leaves are of a green colour. The inhabitants of the deserts, the jerboa, or leaping mice, foxes of the desert, gazelles, lions, etc., are mostly of a yellow or yellowish-brown colour, like the sand of the desert. The polar animals, which live on the ice and snow, are white or grey, like ice and snow. Many of these animals change their colour in summer and winter. In summer, when the snow partly vanishes, the fur of these polar creatures becomes brownish-grey or blackish, like the naked earth, while in winter it again becomes white. Butterflies and insects which hover round the gay and bright flowers are like them in colour. Now, Darwin explains this surprising circumstance quite simply by the fact that such colours as agree with the colour of the habitation are of the greatest use to the animals concerned. If these animals are animals of prey, they will be able to approach the object of their pursuit more safely and with less likelihood of observation, and, in like manner, those animals which are pursued will

be able to escape more easily, if their colour is as little different as possible from that of their surroundings. If therefore originally an animal species varied so as to present cases of all colours, those individuals whose colour most resembled the surroundings must have been most favoured in the struggle for life. They remained more unobserved, maintained and propagated themselves, while those individuals or varieties differently coloured died out.

I have tried to explain, by the same sympathetic selection of colour, the wonderful fact that the majority of pelagic animals—that is, of those which live on the surface of the open sea—are bluish, or completely colourless and transparent, like glass and water itself. Such colourless, glassy animals are met with in the most different classes. To them belong, among fish, the *Helmichthyidæ*, through whose crystalline bodies the words of a book can be read; among the molluscs, the finned snails (*Heteropods*) and sea-butterflies, or whales-food (*Pteropods*); among worms, the *Salpæ*, *Alciope*, and *Sagitta*; further, a great number of pelagic crabs (*Crustacea*), and the greater part of the *Medusæ* *Umbrella-jellies*, (*Discomedusæ*); *Comb-jellies*, (*Ctenophora*). All of these pelagic animals, which float on the surface of the ocean, are transparent and colourless, like glass and like the water itself, while their nearest kin live at the bottom of the ocean, and are coloured and opaque like the inhabitants of the land. This remarkable fact, like the sympathetic colouring of the inhabitants of the earth, can be explained by natural selection. Among the ancestors of the pelagic glass-like animals which showed a different degree of colourlessness and transparency, those that were the most colourless and transparent must have been most favoured

in the active struggle for life which takes place on the surface of the ocean. They were enabled to approach their prey the most easily unobserved, and were themselves least observed by their enemies. Hence they could preserve and propagate themselves more easily than their more coloured and opaque relatives; and finally, by accumulative adaptation and transmission by inheritance, through natural selection, in the course of many generations their bodies would attain that degree of crystal-like transparency and colourlessness which we at present admire in them. (Gen. Morph. ii. 242.)

No less interesting and instructive than homochromic selection is that species of natural selection which Darwin calls "*sexual selection*," which explains the origin of the so-called "secondary sexual characters." We have already mentioned these subordinate sexual characteristics, so instructive in many respects. They comprise those peculiarities of animals and plants which belong only to one of the two sexes, and which do not stand in any direct relation to the act of propagation itself (compare above, p. 244). Such secondary sexual characters occur in great variety among animals. We all know how striking is the difference of the two sexes in size and colour in many birds and butterflies. The male sex is generally the larger and more beautiful. It often possesses special decorations or weapons; as for example, the spur and comb of the cock, the antlers of the stag and deer, etc. All these peculiarities of the two sexes have nothing directly to do with propagation itself, which is effected by the "primary sexual characters," or actual sexual organs.

Now, the origin of these remarkable "secondary sexual characters" is explained by Darwin simply by a choice or

selection which takes place in the propagation of animals. In most animals the number of individuals of both sexes is unequal; either the number of the female or the number of the male individuals is greater, and, as a rule, when the season of propagation approaches, a struggle takes place between the rivals for the possession of the animals of the other sex. It is well known with what vigour and vehemence this struggle is fought out among the higher animals—among mammals and birds—especially among those of polygamous habits. Among gallinaceous birds, where for one cock there are several hens, a severe struggle takes place between the competing cocks for as large a harem as possible. The same is the case with many ruminating animals. Among stags and deer, for instance, at the period of rut, deadly struggles take place between the males for the possession of the females. The secondary sexual character which here distinguishes the males—the antlers of stags and deer—not possessed by the female, is, according to Darwin, the consequence of that struggle. Here the motive and cause determining the struggle is not, as in the case of the struggle for individual existence, self-preservation, but the preservation of the species—propagation. There are numerous passive weapons of defence, as well as active weapons for attack. The lion's mane, not possessed by the female, is evidently such a weapon of defence; it is an excellent means of protection against the bites which the male lions try to inflict on each other's necks when fighting for the females; consequently those males with the strongest manes have the greatest advantage in the sexual struggle. The dewlap of the ox and the comb of the cock are similar defensive weapons. Active weapons of attack, on the other

hand, are the antlers of the stag, the tusks of the boar, the spur of the cock, and the hugely developed pair of jaws in the male stag-beetle; all are instruments employed by the males in the struggle for the females, for annihilating or chasing away their rivals.

In the cases just mentioned, it is the bodily "struggle to the death" which determines the origin of the secondary sexual characters. But, besides these mortal struggles, there are other important competitions in sexual selection, which no less influence the structure of the rivals. These consist principally in the fact that the courting sex tries to please the other by external finery, by beauty of form, or by a melodious voice. Darwin thinks that the beautiful voices of singing birds have principally originated in this way. Many male birds carry on a regular musical contest when they contend for the possession of the females. It is known of several singing birds, that in the breeding season the males assemble in numbers round the females, and let their songs resound before them, and that then the females choose the singers who best please them for their mates. Among other songsters, individual males pour out their songs in the loneliness of the forest in order to attract the females, and the latter follow the most attractive calls. A similar musical contest, though certainly less melodious, takes place among crickets and grasshoppers. The male cricket has on its belly two instruments like drums, and produces with these the sharp chirping notes which the ancient Greeks curiously enough thought beautiful music. Male grasshoppers, partly by using their hind-legs like the bow of a violin against their wing coverings, and partly by rubbing their wing coverings together, bring out tones which are, indeed, not

melodious to us, but which please the female grasshoppers so much that they choose the male who fiddles the best.

Among other insects and birds it is not song or, in fact, any musical accomplishment, but finery or beauty of the one sex which attracts the other. Thus we find that, among most gallinaceous birds, the cocks are distinguished by combs on their heads, or by a beautiful tail, which they can spread out like a fan; as for example, in the case of the peacock and turkey-cock. The magnificent tail of the bird of paradise is also an exclusive ornament of the male sex. In like manner, among very many other birds and very many insects, principally among butterflies, the males are distinguished from the females by special colours or other decorations. These are evidently the results of sexual selection. As the females do not possess these attractions and decorations, we must come to the conclusion that they have been acquired by degrees by the males in the competition for the females, which takes its origin in the selective discrimination of the females.

We may easily picture to ourselves, in detail, the application of this interesting conclusion to the human community. Here, also, the same causes have evidently influenced the development of the secondary sexual characters. The characteristics distinguishing the man, as well as those distinguishing the woman, owe their origin, certainly for the most part, to the sexual selection of the other sex. In antiquity and in the Middle Ages, especially in the romantic age of chivalry, it was the bodily struggles to the death—the tournaments and duels—which determined the choice of the bride; the strongest carried home the bride. In more recent times, however, in our so-called “polished” or “highly civil-

ized" society, competing rivals prefer to contend indirectly by means of musical accomplishments, instrumental performances and song, by bodily charms, natural beauty, or artificial decoration. But by far the most important of these different forms of sexual selection in man is that form which is the most exalted, namely, *psychical selection*, in which the mental excellencies of the one sex influence and determine the choice of the other. The most highly intellectually developed types of men have, throughout generations, when choosing a partner in life, been guided by her excellencies of soul, and have thus transmitted these qualities to their posterity, and they have in this way, more than by any other thing, helped to create the deep chasm which at present separates civilized men from the rudest savages, and from our common animal ancestors. In fact, both the part played by the prevalence of a higher standard of sexual selection, and the part played by the due division of labour between the two sexes, is exceedingly important, and I believe that here we must seek for the most powerful causes which have determined the origin and the historical development of the races of man. (Gen. Morph. ii. 247.) As Darwin, in his exceedingly interesting work, published in 1871, on "The Descent of Man and Sexual Selection,"⁴⁸ has discussed this subject in the most masterly manner, and has illustrated it by most remarkable examples, I refer for further detail to that work.

But now let us look again at two extremely important organic laws which can be explained by the theory of selection, as necessary consequences of natural selection in the struggle for existence. I mean the law of *division of labour*, or *differentiation*, and the law of *progress*, or

perfecting. When the phenomena due to these two laws first became known, through observation of the historical development, the individual development, and the comparative anatomy of animals and plants, naturalists were inclined to trace them to a direct creative influence. It was supposed to be part of the plan of the Creator, acting for a definite purpose, in the course of time to develop the forms of animals and plants more and more variously, and to bring them more and more to a state of perfection. We shall evidently make a great advance in the knowledge of nature if we reject this teleological and anthropomorphic conception, and if we can prove the two laws of Division of Labour and Perfecting to be the necessary consequences of natural selection in the struggle for life.

The first great law which follows directly and of necessity from natural selection, is that of *separation*, or *differentiation*, which is frequently called *division of labour*, or *polymorphism*, and which Darwin speaks of as *divergence of character*. (Gen. Morph. ii. 249). We understand by it the general tendency of all organic individuals to develop themselves more and more diversely, and to deviate from the common primary type. The cause of this general inclination towards differentiation and the formation of heterogeneous forms from homogeneous beginnings is, according to Darwin, simply to be traced to the circumstance that the struggle for life between every two organisms rages all the more fiercely the nearer the relation in which they stand to one another, or the more nearly alike they are. This is an exceedingly important, and in reality an exceedingly simple relation, but it is usually not duly considered.

It must be obvious to every one, that in a field of a certain size, besides the corn-plants which have been sown, a

great number of weeds can exist, and, moreover, in places which could not have been occupied by corn-plants. The more dry and sterile places of the ground, in which no corn-plant would thrive, may still furnish sustenance to weeds of different kinds; and such species and individuals of weeds will more readily be able to exist in such conditions, in proportion as they are suited to adapt themselves to the different parts of the ground. It is the same with animals. It is evident that a much greater number of animal individuals can live together in one and the same limited district, if they are of various and different natures, than if they are all alike. There are trees (for example, the oak) on which a couple of hundred of different species of insects live together. Some feed on the fruits of the tree, others on the leaves, others again on the bark, the root, etc. It would be quite impossible for an equal number of individuals to live on this tree if all were of one species; if, for example, all fed on the bark, or only upon the leaves. Exactly the same is the case in human society. In one and the same small town, only a certain number of workmen can exist, even when they follow different occupations. The division of labour, which is of the greatest use to the whole community, as well as to the individual workman, is a direct consequence of the struggle for life, of natural selection; for this struggle can be sustained more easily the more the activities, and hence, also, the forms of the different individuals deviate from one another. The different function naturally produces its reaction in changing the form, and the physiological division of labour necessarily determines the morphological differentiation, that is, the "divergence of character."³⁷

Now, I beg the reader again to remember that all species

of animals and plants are variable, and possess the capability of adapting themselves to different places or to local relations. The varieties or races of each species, according to the laws of adaptation, deviate all the more from the original primary species, the greater the difference of the new conditions to which they adapt themselves. If we imagine these varieties—which have proceeded from a common primary form—to be disposed in the shape of a branching, radiating bunch, then those varieties will be best able to exist side by side and propagate which are most distant from one another, which stand at the ends of the series, or at the opposite sides of the bunch. Those forms, on the other hand, occupying a middle position—presenting a state of transition—have the most difficult position in the struggle for life. The necessities of life differ most in the two extremes, in the varieties most distant from one another, and consequently these will get into the least serious conflict with one another in the general struggle for life. But the intermediate forms, which have deviated less from the original primary form, require nearly the same necessities of life as the original form, and therefore, in competing for them, they will have to struggle most with, and be most seriously threatened by, its members. Consequently, when numerous varieties of a species live side by side on the same spot of the earth, the extremes, or those forms deviating most from one another, can much more easily continue to exist beside one another than the intermediate forms which have to struggle with each of the different extremes. The intermediate forms will not be able to resist, for any length of time, the hostile influences which the extreme forms victoriously overcome. These alone maintain and propagate

themselves, and at length cease to be any longer connected with the original primary species through intermediate forms of transition. Thus arise "good species" out of varieties. Thus, then, the struggle for life necessarily favours the general divergence of organic forms, that is, the constant tendency of organisms to form new species. This fact does not rest upon any mystic quality, or upon an unknown formative tendency, but upon the interaction of Inheritance and Adaptation in the struggle for life. As the intermediate forms, that is, the individuals in a state of transition, of the varieties of every species die out and become extinct, the process of divergence constantly goes further, and from the extremes forms develop which we distinguish as new species.

Although all naturalists have been obliged to acknowledge the variability and mutability of all species of animals and plants, yet most of them have hitherto denied that the modification or transformation of the organic form surpasses the original limit of the characters of the species. Our opponents cling to the proposition—"However far a species may exhibit deviations from its usual form in a collection of varieties, yet the varieties of it are never so distinct from one another as two really good species." This assertion, which Darwin's opponents usually place at the head of their arguments, is utterly untenable and unfounded. This will become quite clear as soon as we critically compare the various attempts to define the idea of species. No naturalist can answer the question as to what is in reality a "genuine or good species" ("bona species"); yet every systematic naturalist uses this expression every day, and whole libraries have been written on the question as to

whether this or that observed form is a species or a variety, whether it is a really good or a bad species. The most general answer to this question used to be the following: "To one species belong all those individuals which agree in all essential characteristics. Essential characteristics of species are those which remain permanent or constant, and never become modified or vary." But as soon as a case occurred in which the characteristic—which had hitherto been considered essential—did become modified, then it was said, "This characteristic is not essential to the species, for essential characteristics never vary." Those who argued thus evidently moved in a circle, and the naïveté with which this circular method of defining species is laid down in thousands of books as an unassailable truth, and is still constantly repeated, is truly astonishing.

All other attempts which have been made to arrive at a definite and logical determination of the idea of organic "species" have, like the last, been utterly futile, and led to no results. Considering the nature of the case, it cannot be otherwise. The idea of species is just as truly a relative one and not absolute, as is the idea of variety, genus family, order, class, etc. I have proved this in detail in the criticism of the idea of species in my "General Morphology" (Gen. Morph. ii. 323-364). I will waste no more time on this unsatisfactory discussion, and now only add a few words about the *relation of species to hybridism*. Formerly it was regarded as a dogma, that two good species could never produce hybrids which could reproduce themselves as such. Those who thus dogmatized almost always appealed to the hybrids of a horse and donkey, the mule and the hinny, which, truly enough, are seldom able to reproduce

themselves. But the truth is that such unfruitful hybrids are rare examples, and in the majority of cases hybrids of two totally different species are fruitful and able to reproduce themselves. They can almost always fruitfully mix with one or other of the parent species, and sometimes also among themselves; and in this way completely new forms can originate according to the laws of "mixed transmission by inheritance."

Thus, in fact, *hybridism is a source of the origin of new species*, distinct from the source we have hitherto considered—natural selection. I have already spoken occasionally of these *hybrid species* (species hybridæ), especially of the hare-rabbit (*Lepus Darwinii*), which has arisen from the crossing of a male hare and a female rabbit; the goat-sheep (*Capra ovina*), which has arisen from the pairing of a he-goat and ewe; also the different species of thistles (*Cirsium*), brambles (*Rubus*), etc. It is possible that many wild species have originated in this way, as even Linnæus assumed. At all events, these hybrid species, which can maintain and propagate themselves as well as pure species, prove that hybridism cannot serve in any way to give an absolute definition to the idea of species.

I have already mentioned (p. 47) that the many vain attempts to define the idea of species theoretically have nothing whatever to do with the practical distinction of species. The extensive practical application of the idea of species, as it is carried out in systematic zoology and botany, is very instructive as furnishing an example of human folly. Hitherto, by far the majority of zoologists and botanists, in distinguishing and describing the different forms of animals and plants, have endeavoured, above all things, to dis-

tinguish accurately kindred forms as so many "good species." However, it has been found scarcely possible, in any group, to make an accurate and consistent distinction of such "genuine or good species." There are no two zoologists, no two botanists, who agree in all cases as to which of the nearly related forms of a genus are good species, and which are not. All authors have different views about them. In the genus *Hieracium*, for example, one of the commonest genera of European plants, no less than 300 species have been distinguished in Germany alone. The botanist Fries, however, only admits 106, Koch only 52, as "good species," and others accept scarcely 20. The differences in the species of brambles (*Rubus*) are equally great. Where one botanist makes more than a hundred species, a second admits only about one half of that number, a third only five or six, or even fewer species. The birds of Germany have long been very accurately known. Bechstein, in his careful "Natural History of German Birds," has distinguished 367 species, L. Reichenbach 379, Meyer and Wolff 406, and Brehm, a clergyman learned in ornithology, distinguishes even more than 900 different species.

Thus we see that here, and, in fact, in every other domain of systematic zoology and botany, the most arbitrary proceedings prevail, and, from the nature of the case, must prevail. For it is quite impossible accurately to distinguish varieties and races from so-called "good species." *Varieties are commencing species.* The variability or adaptability of species, under the influence of the struggle for life, necessitates the continual and progressive separation or differentiation of varieties, and the perpetual delimitation of new forms. Whenever these are maintained throughout a number of

generations by inheritance, whilst the intermediate forms die out, they form independent "new species." The origin of new species by division of labour, or separation, divergence, or differentiation of varieties, is therefore a *necessary consequence of natural selection*.³⁷

The same kind of interest attaches to a second great law which we deduce from natural selection, and which is, indeed, closely connected with the law of Divergence, but in no way identical with it ; namely, the law of *Progress* (progressus), or *Perfecting* (teleosis). (Gen. Morph. ii. 257). This great and important law, like the law of differentiation, had long been empirically established by palæontological experience, before Darwin's Theory of Selection gave us the key to the explanation of its cause. The most distinguished palæontologists have pointed out the law of progress as the most general result of their investigations of fossil organisms. This has been specially done by Bronn, whose investigations on the laws of construction¹⁸ and the laws of the development¹⁹ of organisms, although little heeded, are excellent, and deserve most careful consideration. The general results of the law of differentiation and the law of progress, at which Bronn arrived by a purely mechanical hypothesis, and by exceedingly accurate, laborious, and careful investigations, are brilliant confirmations of the truth of these two great laws which we deduce as necessary inferences from the theory of selection.

The law of progress or of perfecting establishes the exceedingly important fact, on the ground of palæontological experience, that in successive periods of this earth's history, a continual increase in the perfection of organic formations has taken place. Since that inconceivably

remote period in which life on our planet began with the spontaneous generation of Monera, organisms of all groups, both collectively as well as individually, have continually become more perfectly and highly developed. The steadily increasing variety of living forms has always been accompanied by progress in organization. The lower the strata of the earth in which the remains of extinct animals and plants lie buried, that is, the older the strata are, the more simple and imperfect are the forms which they contain. This applies to organisms collectively, as well as to every single large or small group of them, setting aside, of course, those exceptions which are due to the process of degeneration, which we shall discuss hereafter.

As a confirmation of this law I shall mention only the most important of all animal groups, the tribe of vertebrate animals. The oldest fossil remains of vertebrate animals known to us belong to the lowest class, that of Fishes. Upon these there followed later more perfect Amphibious animals, then Reptiles, and lastly, at a much later period, the most highly organized classes of vertebrate animals, Birds and Mammals. Of the latter only the lowest and most imperfect forms, without placenta, appeared at first, such as are the pouched animals (Marsupials), and afterwards, at a much later period, the more perfect mammals, with placenta. Of these, also, at first only the lower kinds appeared, the higher forms later; and not until the late tertiary period did man gradually develop out of these last.

If we follow the historical development of the vegetable kingdom we shall find the same law operative there. Of plants there existed at first only the lowest and most imperfect classes, the Algæ or tangles. Later there followed

the group of Ferns or Filicinae (ferns, pole-reeds, scale-plants, etc.). But as yet there existed no flowering plants, or Phanerogama. These originated later with the Gymnosperms (firs and cypresses), whose whole structure stands far below that of the other flowering plants (Angiosperms), and forms the transition from the group of fern-like plants to the Angiosperms. These latter developed at a still later date, and among them there were at first only flowering plants without corolla (Monocotyledons and Monochlamyds); only later were there flowering plants with a corolla (Dichlamyds). Finally, again, among these the lower polypetalous plants preceded the higher gamopetalous plants. The whole series thus constitutes an irrefutable proof of the great law of progressive development.

Now, if we ask what is the cause of this fact, we again, just as in the case of differentiation, come back to natural selection in the struggle for life. If once more we consider the whole process of natural selection, how it operates through the complicated interaction of the different laws of Inheritance and Adaptation, we shall recognize not only divergence of character, but also the perfecting of structure to be the direct and necessary result of it. We can trace the same thing in the history of the human race. Here, too, it is natural and necessary that the progressive division of labour constantly furthers mankind, and urges every individual branch of human activity into new discoveries and improvements. This progress itself universally depends on differentiation, and is consequently, like it, a direct result of natural selection in the struggle for life.

CHAPTER XII.

LAWS OF DEVELOPMENT OF ORGANIC TRIBES AND OF INDIVIDUALS. PHYLOGENY AND ONTOGENY.

Laws of the Development of Mankind: Differentiation and Perfecting.
—Mechanical Cause of these two Fundamental Laws.—Progress without Differentiation, and Differentiation without Progress.—Origin of Rudimentary Organs by Non-use and Discontinuance of Habit.—Ontogenesis, or Individual Development of Organisms.—Its General Importance.—Ontogeny, or the Individual History of Development of Vertebrate Animals, including Man.—The Fructification of the Egg.—Formation of the three Germ Layers.—History of the Development of the Central Nervous System, of the Extremities, of the Branchial Arches, and of the Tail of Vertebrate Animals.—Causal Connection and Parallelism of Ontogenesis and Phylogenesis, that is of the Development of Individuals and Tribes.—Causal Connection of the Parallelism of Phylogenesis and of Systematic Development.—Parallelism of the three Organic Series of Development.

If man wishes to understand his position in nature, and to comprehend as natural facts his relations to the phenomena of the world cognisable by him, it is absolutely necessary that he should compare human with extra-human phenomena, and, above all, with animal phenomena. We have already seen that the exceedingly important physiological laws of Inheritance and Adaptation apply to the human organism in the same manner as to the animal and vegetable kingdoms, and in both cases interact with one another. Consequently, natural selection in the struggle

for life acts so as to transform human society, just as it modifies animals and plants, and in both cases constantly produces new forms. The comparison of the phenomena of human and animal transformation is especially interesting in connection with the laws of divergence and progress, the two fundamental laws which, at the end of the last chapter, we proved to be direct and necessary consequences of natural selection in the struggle for life.

A comparative survey of the history of nations, or what is called "universal history," will readily yield to us, as the first and most general result, evidence of a continually *increasing variety* of human activities, both in the life of individuals and in that of families and states. This differentiation or separation, this constantly increasing divergence of human character and the form of human life, is caused by the ever advancing and more complete division of labour among individuals. While the most ancient and lowest stages of human civilization show us throughout the same rude and simple conditions, we see in every succeeding period of history, among different nations, a greater variety of customs, practices, and institutions. The increasing division of labour necessitates an increasing variety of forms corresponding to it. This is expressed even in the formation of the human face. Among the lowest tribes of nations, most of the individuals resemble one another so much that European travellers often cannot distinguish them at all. With increasing civilization the physiognomy of individuals becomes differentiated, and finally, among the most highly civilized nations, the English and Germans, the divergence in the characters of the face is so great that we very rarely mistake one face for another.

The second great fundamental law which is obvious in the history of nations is the great law of progress or perfecting. Taken as a whole, the history of man is the history of his *progressive development*. It is true that everywhere and at all times we may notice individual retrogressions, or observe that crooked roads towards progress have been taken, which lead only towards one-sided and external perfecting, and thus deviate more and more from the higher goal of internal and enduring perfecting. However, on the whole, the movement of development of all mankind is and remains a progressive one, inasmuch as man continually removes himself further from his ape-like ancestors, and continually approaches nearer to his own ideal.

Now, if we wish to know what causes actually determine these two great laws of development in man, namely, the law of divergence and the law of progress, we must compare them with the corresponding laws of development in animals, and on a close examination we shall inevitably come to the conclusion that the phenomena, as well as their causes, are exactly the same in the two cases. The course of development in man, just as in that of animals, being directed by the two fundamental laws of differentiation and perfecting, is determined solely by purely mechanical causes, and is solely the necessary consequence of natural selection in the struggle for life.

Perhaps in the preceding discussion the question has presented itself to some—"Are not these two laws identical? Is not progress in all cases necessarily connected with divergence?" This question has often been answered in the affirmative, and Carl Ernst Bar, for example, one of the greatest investigators in the domain of the history of de-

velopment, has set forth the following proposition as one of the principal laws in the ontogenesis of the animal body:—
 “The degree of development (or perfecting) depends on the stage of separation (or differentiation) of the parts.”²⁰
 Correct as this proposition may be on the whole, yet it is not universally true. In many individual cases it can be proved that divergence and progress by no means always coincide. *Every progress is not a differentiation, and every differentiation is not a progress.*

Naturalists, guided by purely anatomical considerations, had already set forth the law relating to progress in organization, that the perfecting of an organism certainly depends, for the most part, upon the division of labour among the individual organs and parts of the body, but that there are also other organic transformations which determine a progress in organization. One, in particular, which has been generally recognized, is the *numerical diminution of identical parts*. If, for example, we compare the lower articulated animals of the crustacean group, which possess numerous pairs of legs, with spiders which never have more than four pairs of legs, and with insects which always possess only three pairs of legs, we find this law, for which a great number of examples could be adduced, confirmed. The numerical diminution of pairs of legs is a progress in the organization of articulated animals. In like manner the numerical diminution of corresponding vertebral joints in the trunk of vertebrate animals is a progress in their organization. Fishes and amphibious animals with a very large number of identical vertebral joints are, for this very reason, less perfect and lower than birds and mammals, in which the vertebral joints, as a

whole, are not only very much more differentiated, but in which the number of corresponding vertebræ is also much smaller. Further, according to the same law of numerical diminution, flowers with numerous stamens are more imperfect than the flowers of kindred plants with a smaller number of stamens, etc. If therefore originally a great number of homogeneous parts exist in an organic body, and if, in the course of very many generations, this number be gradually decreased, this transformation will be an example of perfecting.

Another law of progress, which is quite independent of differentiation, nay, even appears to a certain extent opposed to it, is the law of *centralization*. In general the whole organism is the more perfect the more it is organized as a unit, the more the parts are subordinate to the whole, and the more the functions and their organs are centralized. Thus, for example, the system of blood-vessels is most perfect where a centralized heart exists. In like manner, the dense mass of marrow which forms the spinal cord of vertebrate animals, and the ventral cord of the higher articulated animals, is more perfect than the decentralized chain of ganglia of the lower articulated animals, and the scattered system of ganglia in the molluscs. Considering the difficulty of explaining these complicated laws of progress in detail, I cannot here enter upon a closer discussion of them, and must refer to Bronn's excellent "*Morphologischen Studien*," and to my "*General Morphology*" (Gen. Morph. i. 370, 550; ii. 257-266).

Just as we have become acquainted with phenomena of progress, quite independent of divergence, so we shall, on the other hand, very often meet with divergencies which

are no perfecting, but which are rather the contrary, that is retrogressions or degenerations. It is easy to see that the changes which every species of animal and plant experiences cannot always be improvements. But rather many phenomena of differentiation, which are of direct advantage to the organism itself, are yet, in a wider sense, detrimental, inasmuch as they lessen its general capabilities. Frequently a relapse to simpler conditions of life takes place, and by adaptation to them a divergence in a retrograde direction. If, for instance, organisms which have hitherto lived independently accustom themselves to a parasitical life, they thereby degenerate or retrograde. Such animals, which hitherto had possessed a well-developed nervous system and quick organs of sense, as well as the power of moving freely, lose these when they accustom themselves to a parasitical mode of life; they consequently retrograde more or less. There the differentiation viewed by itself is a degeneration, although it is advantageous to the parasitical organism. In the struggle for life such an animal, which has accustomed itself to live at the expense of others, by retaining its eyes and apparatus of motion, which are of no more use to it, would only expend so much material uselessly; and when it loses these organs, then a great quantity of nourishment which was employed for the maintenance of these parts, benefits other parts. In the struggle for life between the different parasites, therefore, those which make least pretensions will have advantage over the others, and this favours their degeneration.

Just as this is found to be the case with the whole organism, so it is also with the parts of the body of an individual organism. A differentiation of parts, which

leads to a partial degeneration, and finally even to the loss of individual organs, is, when looked at by itself, a degeneration, but yet may be advantageous to the organism in the struggle for life. It is easier to fight when useless baggage is thrown aside. Hence we meet everywhere, in the more highly-developed animal and vegetable bodies, processes of divergence, the essence of which is that they cause the degeneration, and finally the loss, of particular parts. And at this point the most important and instructive of all the series of phenomena bearing upon the history of organisms presents itself to us, namely, that of *rudimentary or degenerate organs*.

It will be remembered that even in my first chapter I considered this exceedingly remarkable series of phenomena, from a theoretical point of view, as one of the most important and most striking proofs of the truth of the doctrine of descent. We designated as rudimentary organs those parts of the body which are arranged for a definite purpose and yet are without function. Let me remind the reader of the eyes of those animals which live in the dark in caves and underground, and which consequently never can use them. In these animals we find real eyes hidden under the skin, frequently developed exactly as are the eyes of animals which really see; and yet these eyes never perform any function, indeed cannot, simply for the reason that they are covered by an opaque membrane, and consequently no ray of light falls upon them (compare above, p. 13). In the ancestors of these animals, which lived in open daylight, the eyes were well developed, covered by a transparent horny capsule (cornea), and actually served the purpose of

seeing. But as the animals gradually accustomed themselves to an underground mode of life, and withdrew from the daylight and no longer used their eyes, these became degenerated.

Very clear examples of rudimentary organs, moreover, are the wings of animals which cannot fly; for example, the wings of the running birds, like the ostrich, emeu, cassowary, etc., the legs of which have become exceedingly developed. These birds having lost the habit of flying, have consequently lost the use of their wings; however, the wings are still there, although in a crippled form. We very frequently find such crippled wings in the class of insects, most members of which can fly.

From reasons derived from comparative anatomy and other circumstances, we can with certainty draw the inference that all insects now living (all dragon-flies, grasshoppers, beetles, bees, bugs, flies, butterflies, etc.) have originated from a single common parental form, from a primary insect which possessed two well-developed pairs of wings, and three pairs of legs. Yet there are very many insects in which either one or both pairs of wings have become more or less degenerated, and many in which they have even completely disappeared. For example, in the whole order of flies, or *Diptera*, the hinder pair of wings—in the bee-parasites, or *Strepsiptera*, on the other hand, the fore pair of wings—have become degenerated or entirely disappeared. Moreover, in every order of insects we find individual genera, or species, in which the wings have more or less degenerated or disappeared. The latter is the case especially in parasites. The females have frequently no wings, whereas the males have; for instance, in the case of glow-

worms (*Lampyrus*), *Strepsiptera*, etc. This partial or complete degeneration of the wings of insects has evidently arisen from natural selection in the struggle for life. For we find insects without wings living under circumstances where flying would be useless, or even decidedly injurious to them. If, for example, insects living on islands fly about much, it may easily happen that when flying they are blown into the sea by the wind, and if (as is always the case) the power of flying is differently developed in different individuals, then those which fly badly have an advantage over those which fly well ; they are less easily blown into the sea, and remain longer in life than the individuals of the same species which fly well. In the course of many generations, by the action of natural selection, this circumstance must necessarily leads to a complete suppression of the wings. If this conclusion had been arrived at on purely theoretical grounds, we might be pleased to find its truth established by facts. For upon isolated islands the proportion of wingless insects to those possessing wings is surprisingly large, much larger than among the insects inhabiting continents. Thus, for example, according to Wollaston, of the 550 species of beetles which inhabit the island of Madeira, 220 are wingless, or possess such imperfect wings that they can no longer fly ; and of the 29 genera which belong to that island exclusively, no less than 23 contain such species only. It is evident that this remarkable circumstance does not need to be explained by the special wisdom of the Creator, but is sufficiently accounted for by natural selection, because in this case the hereditary disuse of the wings, the discontinuance of flying in the presence of dangerous winds, has been very advantageous in the

struggle for life. In other wingless insects the want of wings has been advantageous for other reasons. Viewed by itself, the loss of wings is a degeneration, but in these special conditions of life it is advantageous to the organism in the struggle for life.

Among other rudimentary organs I may here, by way of example, further mention the lungs of serpents and serpent-like lizards. All vertebrate animals possessing lungs, such as amphibious animals, reptiles, birds, and mammals, have a pair of lungs, a right and a left one. But in cases where the body is exceedingly thin and elongated, as in serpents and serpent-like lizards, there is no room for the one lung by the side of the other, and it is an evident advantage to the mechanism of respiration if only one lung is developed. A single large lung here accomplishes more than two small ones side by side would do ; and consequently, in these animals, we invariably find only the right or only the left lung fully developed. The other is completely aborted, although existing as a useless rudiment. In like manner, in all birds the right ovary is aborted and without function ; only the left one is developed, and yields all the eggs.

I mentioned in the first chapter that man also possesses such useless and superfluous rudimentary organs, and I specified as such the muscles which move the ears. Another of them is the rudiment of the tail which man possesses in his 3—5 tail vertebræ, and which, in the human embryo, stands out prominently during the first two months of its development (compare Plates II. and III.). It afterwards becomes completely hidden. The rudimentary little tail of man is an irrefutable proof of the fact that he is descended from tailed ancestors. In woman the tail is generally

by one vertebra longer than in man. There still exist rudimentary muscles in the human tail which formerly moved it.

Another case of human rudimentary organs, only belonging to the male, and which obtains in like manner in all male mammals, is furnished by the mammary glands on the breast, which, as a rule, are active only in the female sex. However, cases of different mammals are known, especially of men, sheep, and goats, in which the mammary glands were fully developed in the male sex, and yielded milk as food for their offspring. I have already mentioned before (p. 12) that the rudimentary auricular muscles in man can still be employed to move their ears, by some persons who have perseveringly practised them. In fact, rudimentary organs are frequently very differently developed in different individuals of the same species; in some they are tolerably large, in others very small. This circumstance is very important for their explanation, as is also the other circumstance that generally in embryos, or in a very early period of life, they are much larger and stronger in proportion to the rest of the body than they are in fully developed and fully grown organisms. This can, in particular, be easily pointed out in the rudimentary sexual organs of plants (stamens and pistil), which I have already mentioned. They are proportionately much larger in the young flower-bud than in the mature flower.

I have remarked (p. 15) that rudimentary or suppressed organs were the strongest supports of the monistic or mechanical conception of the universe. If its opponents, the dualists and teleologists, understood the immense significance of rudimentary organs, it would put them into a state

of despair. Their ludicrous attempts to explain that rudimentary organs were given to organisms by the Creator "for the sake of symmetry," or "as a formal provision," or "in consideration of his general plan of creation," sufficiently prove the utter impotence of their perverse conception of the universe. I must here repeat that, even if we knew absolutely nothing of the other phenomena of development, we should be obliged to believe in the truth of the Theory of Descent, solely on the ground of the existence of rudimentary organs. Not one of its opponents has been able to throw even a feeble glimmer of an acceptable explanation upon these exceedingly remarkable and important phenomena. There is scarcely any highly developed animal or vegetable form which has not some rudimentary organs, and in most cases it can be shown that they are the products of natural selection, and that they have become suppressed by disuse. It is the reverse of the process of formation in which new organs arise from adaptation to certain conditions of life, and by the use of parts as yet incompletely developed. It is true our opponents usually maintain that the origin of altogether new parts is completely inexplicable by the Theory of Descent. However, I distinctly assert that to those who possess a knowledge of comparative anatomy and physiology this matter does not present the slightest difficulty. Every one who is familiar with comparative anatomy and the history of development will find as little difficulty about the origin of completely new organs as about the utter disappearance of rudimentary organs. The disappearance of the latter, viewed by itself, is the converse of the origin of the former. Both processes are particular phenomena of differentiation, which, like all others, can be explained quite

simply and mechanically by the action of natural selection in the struggle for life.

The infinitely important study of rudimentary organs and their origin, the comparison of their palæontological and embryological development, now naturally leads us to the consideration of one of the most important and instructive of all biological phenomena, namely, the parallelism which the phenomena of progress and divergence present to us in three different series. When, in the last chapter, we spoke of perfecting and division of labour, we understood by those words progress and separation, and those changes effected by them, which in the long and slow course of the earth's history have led to a continual variation of the flora and fauna, to the origin of new and to the disappearance of ancient species of animals and plants. Now, if we follow the origin, the development, and the life of every single organic individual, we meet with exactly the same phenomena of progress and differentiation. The individual development, or the *ontogenesis* of every single organism, from the egg to the complete form is nothing but a growth attended by a series of diverging and progressive changes. This applies equally to animals, plants, and protista. If, for example, we consider the ontogeny of any mammal, of man, of an ape, or of a pouched animal, or if we follow the individual development of any other vertebrate animal of another class, we everywhere find essentially the same phenomena. Every one of these animals develops itself originally out of a single cell, the egg. This cell increases by self-division, and forms a number of cells, and by the growth of this accumulation of cells, by the divergent development of originally identical

cells, by the division of labour among them, and by their perfecting, there arises the perfect organism, the complicated composition of which excites our admiration.

It seems to me here indispensable to draw attention more closely to those infinitely important and interesting processes which accompany *ontogenesis*, or *the individual development of organisms*, and especially to that of vertebrate animals, man included. I wish especially to recommend these exceedingly remarkable and instructive phenomena to the reader's most careful consideration, first, because they are among the strongest supports of the Theory of Descent, and secondly, because, considering their immense general importance, they have hitherto been properly considered only by a few privileged persons.

We cannot indeed but be astonished when we consider the deep ignorance which still prevails, in the widest circles, about the facts of the individual development of man and organisms in general. These facts, the universal importance of which cannot be estimated too highly, were established, in their most important outlines, even more than a hundred years ago, in 1759, by the great German naturalist Caspar Friedrich Wolff, in his classical "*Theoria Generationis*." But, just as Lamarck's Theory of Descent, founded in 1809, lay dormant for half a century, and was only awakened to new and imperishable life in 1859, by Darwin, in like manner Wolff's Theory of Epigenesis remained unknown for nearly half a century; and it was only after Oken, in 1806, had published his history of the development of the intestinal tube, and after Meckel, in 1812, had translated Wolff's work (written in Latin) on the same subject into German, that Wolff's theory of epigenesis became more gener-

ally known, and formed the foundation of all subsequent investigations of the history of individual development. The study of ontogenesis now received a great stimulus, and soon there appeared the classical investigations of the two friends, Christian Pander (1817) and Carl Ernst Bär (1819). Bär, in his remarkable "*Entwicklungsgeschichte der Thiere*,"²⁰ worked out the ontogeny of vertebrate animals in all its important facts. He carried out a series of such excellent observations, and illustrated them by such profound philosophical reflections, that his work became the foundation for a thorough understanding of this important group of animals, to which, of course, man also belongs. The facts of embryology alone would be sufficient to solve the question of man's position in nature, which is the highest of all problems. Look attentively at and compare the eight figures which are represented on the adjoining Plates II. and III., and it will be seen that the philosophical importance of embryology cannot be too highly estimated.

We may well ask, What do our so-called "educated" circles, who think so much of the high civilization of the 19th century, know of these most important biological facts, of these indispensable foundations for understanding their own organism? How much do our speculative philosophers and theologians know about them, who fancy they can arrive at an understanding of the human organism by mere guesswork or divine inspiration? What indeed do the majority of naturalists, not excepting the majority of the so-called "zoologists" (including the entomologists!), know about them?

The answer to this question tells much to the shame of the persons above indicated, and we must confess, willingly

or unwillingly, that these invaluable facts of human ontogeny are, even at the present day, utterly unknown to most people, or are in no way valued as they deserve to be. It is in the face of such a condition of things as this that we see clearly upon what a wrong and one-sided road the much vaunted culture of the 19th century still moves. Ignorance and superstition are the foundations upon which most men construct their conception of their own organism and its relation to the totality of things; and these palpable facts of the history of development, which might throw the light of truth upon them, are ignored. It is true these facts are not calculated to excite approval among those who assume a thorough difference between man and the rest of nature, and who will not acknowledge the animal origin of the human race. That origin must be a very unpleasant truth to members of the ruling and privileged castes in those nations among which there exists an hereditary division of social classes, in consequence of false ideas about the laws of inheritance. It is well known that, even in our day, in many civilized countries the idea of hereditary grades of rank goes so far, that, for example, the aristocracy imagine themselves to be of a nature totally different from that of ordinary citizens, and nobles who commit a disgraceful offence are punished by being expelled from the caste of nobles, and thrust down among the pariahs of "vulgar citizens." What are these nobles to think of the noble blood which flows in their privileged veins, when they learn that all human embryos, those of nobles as well as commoners, during the first two months of development, are scarcely distinguishable from the tailed embryos of dogs and other mammals?

As the object of these pages is solely to further the general knowledge of natural truths, and to spread, in wider circles, a natural conception of the relations of man to the rest of nature, I shall be justified if I do not pay any regard to the widely-spread prejudice in favour of an exceptional and privileged position for man in creation, and simply give here the embryological facts from which the reader will be able to draw conclusions affirming the groundlessness of those prejudices. I wish all the more to entreat him to reflect carefully upon these facts of ontogeny, as it is my firm conviction that a general knowledge of them can only promote the intellectual advance, and thereby the mental perfecting, of the human race.

Amidst all the infinitely rich and interesting material which lies before us in the ontogeny of vertebrate animals, that is, in the history of their individual development, I shall here confine myself to showing some of those facts which are of the greatest importance to the Theory of Descent in general, as well as in its special application to man. Man is at the beginning of his individual existence a simple egg, a single little cell, just the same as every animal organism which originates by sexual generation. The human egg is essentially the same as that of all other mammals, and cannot be distinguished from the egg of the higher mammals. The egg represented in Fig. 5 might be that of a man or an ape as well as of a dog, a horse, or any other mammal. Not only the form and structure, but even the size of the egg in most mammals is the same as in man, namely, about the 120th part of an inch in diameter, so that the egg under favorable circumstances, with the naked eye, can just be perceived as a small speck. The differences which really

exist between the eggs of different mammals and that of man do not consist in the form, but in the chemical mixture, in the molecular composition of the albuminous combination of carbon, of which the egg essentially consists. These minute individual differences of all eggs, which depend upon indirect or potential adaptation (and especially upon the law of individual adaptation), are indeed not directly perceptible to the exceedingly imperfect senses of man, but are cognisable through indirect means, as the primary causes of the difference of all individuals.

The human egg is, like that of all other mammals, a small globular bladder, which contains all the constituent parts of a simple organic cell (Fig. 5). The most essential

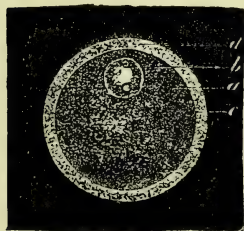


FIG. 5.—The human egg a hundred times enlarged. *a.* The kernel speck, or nucleolus (the so-called germinal spot of the egg). *b.* Kernel, or nucleus (the so-called germinal vesicle of the egg). *c.* Cell-substance, or protoplasm (so-called yolk of the egg). *d.* Cell-membrane (the yolk-membrane of the egg; in mammals, on account of its transparency, called zona pellucida). The eggs of other mammals are of the same form.

parts of it are the mucous cell-substance, or the protoplasma (*c*), which in an egg is called the “yolk,” and the cell-kernel, or nucleus (*b*), surrounded by it, which is here called by the special name of the “germinal vesicle.” The latter is a delicate, clear, glassy globule of albumen, of about 1-600th part of an inch in diameter, and surrounds a still smaller, sharply-marked, rounded granule (*a*), the kernel-speck, or the nucleolus of the cell (in the egg it is called the “germinal spot”). The outside of the globular egg-cell of a mammal is surrounded by a thick pellucid membrane, the cell-membrane

or yolk-membrane, which here bears the special name of *zona pellucida* (*d*). The eggs of many lower animals (for example of many *Medusæ*) differ from this in being *naked* cells, as the outer covering, or cell-membrane, is wanting.

As soon as the egg (ovulum) of the mammal has attained its full maturity, it leaves the ovary of the female, in which it originates, and passes into the oviduct, and through this narrow passage into the wider pouch or womb (uterus). If, meanwhile, the egg is fructified by the male seed (sperm), it develops itself in this pouch into an embryo, and does not leave it until perfectly developed and capable of coming into the world at birth as a young mammal.

The variations of form and transformations which the fructified egg must go through within the uterus before it assumes the form of the mammal are exceedingly remarkable, and proceed from the beginning in man, in precisely the same way as in the other mammals. At first the fructified egg of the mammal acts as a single-celled organism, which is about to propagate independently and increase itself; for example, an *Amceba* (compare Fig. 2, p. 188). In point of fact the simple egg-cell becomes two, by the process of cell-division which I have previously described. There arise from the single germinal spot (the small kernel-speck of the original simple egg-cell) two new kernel-specks, and then in like manner, out of the germinal vesicle (the nucleus), two new cell-kernels. Then, and not until then, does the globular protoplasm first separate itself by an equatorial furrow into two halves, in such a manner that each half encloses one of the two kernels, together with its kernel-speck. Thus the simple egg-cell, within the

original cellular membrane, has become two naked cells, each possessing its own kernel (Fig. 6).

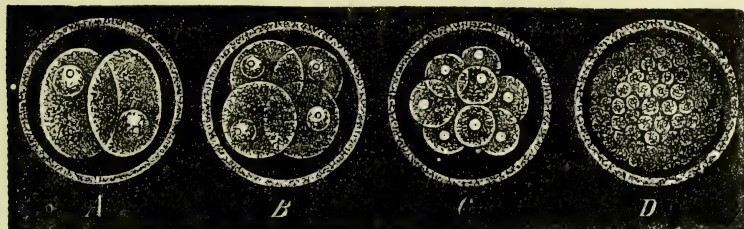


FIG. 6.—First commencement of the development of a mammal's egg, the so-called "yolk-cleavage" (propagation of the egg-cell by repeated self-division). A. The egg, by the formation of the first furrow, falls into two cells. B. These by division fall into four cells. C. These latter have fallen into eight cells. D. By continued division a globular mass of numerous cells has arisen.

The same process of cell-division now repeats itself several times in succession. In this way, from two cells (Fig. 6 A) there arise four (Fig. 6 B); from four, eight (Fig. 6 C); from eight, sixteen; from these, thirty-two, etc. Each time the division of the kernel-speck precedes that of the kernel; this, again, precedes that of the cell-substance, or protoplasm. As the division of the latter always commences with the formation of a superficial annular *furrow*, or cleft, the whole process is usually called the *furrowing of the egg*, or *yolk-cleavage*, and the products of it, that is, the cells arising from the continued halving, are called the *cleavage spheres*. However, the whole process is nothing more than a simple, oft-repeated *division of cells*, and the products of it are actual, naked *cells*. Finally, through the continued division or "furrowing" of the mammal's egg, there arises a mulberry-shaped ball, which is composed of a

great number of small spheres, naked cells, containing kernels (Fig. 6 *D*). These cells are the materials out of which the body of the young mammal is constructed. Every one of us has once been such a simple mulberry-shaped ball, composed only of small equi-formal cells.

The further development of the globular lump of cells, which now represents the young body of the mammal, consists first in its changing into a globular bladder, as fluid accumulates within it. This bladder is called the germ-bladder (*vesicula blastodermica*). Its wall is at first composed of merely equi-formal cells. But soon, at one point on the wall, arises a disc-shaped thickening, as the cells here increase rapidly, and this thickening is now the foundation of the actual body of the germ or embryo, while the other parts of the germ-bladder serve only for its nutrition. The thickened disc, or foundation of the embryo, soon assumes an oblong, and then a fiddle-shaped form, in consequence of its right and left walls becoming convex (Fig. 7, p. 304). At this stage of development in the first form of their germ or embryo, not only all mammals, including man, but even all vertebrate animals in general—birds, reptiles, amphibious animals, and fishes—can either not be distinguished from one another at all, or only by very unessential differences, such as the arrangement of the egg-coverings. In all the whole body consists of nothing but a quite simple, oblong, oval, or violin-shaped thin disc, which is composed of three closely connected membranes or plates, lying one above another. Each of the three plates or layers of the germ consists simply of cells all exactly like one another; but each layer has a different function in the building up of the vertebrate animal body. Out of the upper or outer germ-

layer arises solely the outer skin (epidermis), together with the central parts of the nervous system (spinal marrow and brain); out of the lower or inner layer arises only the inner delicate skin (epithelium) which lines the whole intestinal tube from the mouth to the anus, together with all the glands connected with it (lung, liver, salivary glands, etc); out of the middle germ-layer lying between the two others arise all the other organs, muscles, bones, blood-vessels. Now, the processes by which the various and exceedingly complicated parts of the fully-formed body of vertebrate animals arise out of such simple material—out of the three germ-layers composed only of cells—are, in the first place, the repeated division, and consequently the increase of cells; in the second place, the division of labour or differentiation of these cells; and thirdly, the union of the variously developed or differentiated cells, for the formation of the different organs. Thus arises the gradual progress or perfecting which can be traced step by step in the development of the embryonic body. The simple embryonic cells, which are to constitute the body of the vertebrate animal, stand in the same relation to each other as citizens who wish to found a state. Some take to one occupation, others to another, and work together for the good of the whole. By this division of labour, or differentiation, and the perfecting (the organic progress) which is connected with it, it becomes possible for the whole state to accomplish undertakings which would have been impossible to the single individual. The whole body of the vertebrate animal, like every other many-celled organism, is a republican state of cells, and consequently it can accomplish organic functions which the individual cell, as a solitary individual

(for example, an Amoeba, or a single-celled plant), could never perform.

No sensible person supposes that carefully devised institutions, which have been established for the good of the whole, as well as for the individual, in every human state, are the results of the action of a personal and supernatural Creator, acting for a definite purpose. On the contrary, every one knows that these useful institutions of organization in the state are the consequences of the co-operation of the individual citizens and their common government, as well as of adaptation to the conditions of existence of the outer world. Just in the same way we must judge of the many-celled organism. In it also all the useful arrangements are solely the natural and necessary result of the co-operation, differentiation, and perfecting of the individual citizens—the cells—and by no means the artificial arrangements of a Creator acting for a definite purpose. If we rightly consider this comparison, and pursue it further, we can distinctly see the perversity of that dualistic conception of nature which discovers the action of a creative plan of construction in the various adaptations of the organization of living things.

Let us pursue the individual development of the vertebrate animal body a few stages further, and see what is next done by the citizens of this embryonic organism. In the central line of the violin-shaped disc, which is composed of the three cellular germ-layers, there arises a straight delicate furrow, the so-called "primitive streak," by which the violin-shaped body is divided into two equal lateral halves—a right and a left part or "antimer." On both sides of that streak or furrow, the upper or external germ-layer rises in

the form of a longitudinal fold, and both folds then grow together over the furrow in the central line, and thus form a cylindrical tube. This tube is called the marrow-tube, or medullary canal, because it is the foundation of the central nervous system, the *spinal marrow* (medulla spinalis). At first it is pointed both in front and behind, and it remains so for life in the lowest vertebrate animal, the brainless, skullless Lancelet (*Amphioxus*). But in all other vertebrate animals, which we distinguish from the latter as skulled animals, or Craniota, a difference between the fore and hinder end of the marrow tube soon becomes visible, the fore end becoming dilated, and changing into a roundish bladder, the foundation of the *brain*.

In all Craniota, that is, in all vertebrate animals possessing skull and brain, the brain, which is at first only the bladder-shaped dilatation of the anterior end of the spinal marrow, divides into five bladders lying one behind the other, four superficial, transverse in-nippings being formed. These *five brain-bladders*, out of which afterwards arise all the different parts of the intricately constructed brain, can be seen in their original condition in the embryo represented in Fig. 7. It is just the same whether we examine the embryo of a dog, a fowl, a lizard, or any other higher vertebrate animal. For the embryos of the different skulled animals (at least the three higher classes of them, the reptiles, birds and mammals) cannot be in any way distinguished at the stage represented in Fig. 7. The whole form of the body is as yet exceedingly simple, being merely a thin, leaf-like disc. Face, legs, intestines, etc., are as yet completely wanting. But the five bladders are already quite distinct from one another.

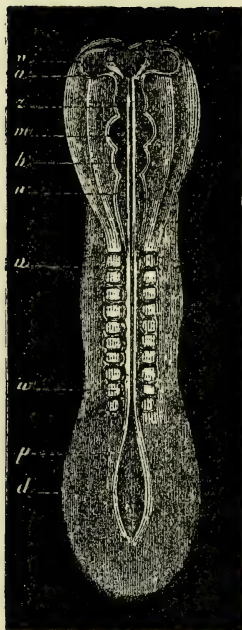


FIG. 7.—Embryo of a mammal or bird, in which the five brain-bladders have just commenced to develop. *v.* Fore brain. *z.* Twixt brain. *m.* Mid brain. *h.* Hind brain. *n.* After brain. *p.* Spinal-marrow. *a.* Eye-bladders. *v.* Primitive vertebræ. *d.* Spinal-axis or notochord.

The *first* bladder, the *fore brain* (*a*), is in so far the most important that it principally forms the hemispheres of the so-called larger brain (cerebrum), that part which is the seat of the higher mental activities. The more these activities are developed in the series of vertebrate animals, the more do the two lateral halves of the fore brain, or the hemispheres, grow at the expense of the other bladders, and overlap them in front and from above. In man, where they are most strongly developed, agreeing with his higher mental activity, they eventually almost entirely cover the other parts from above (compare Plates II. and III.) The *second* bladder, the *twixt brain* (*z*), forms that portion of the brain which is called *the centre of sight*, and stands in the closest relation to the eyes (*a*), which grow right and left out of the fore brain in the shape of two bladders, and later lie at the bottom of the twixt brain. The *third* bladder, the *mid brain* (*m*), for the most part vanishes in the formation of the so-called *four bulbs*, a bossy portion of the brain, which is strongly developed in reptiles and birds (Fig. *E, F*, Plate II.), whereas in mammals it recedes

much more (Fig. *G*, *H*, Plate III.). The *fourth* bladder, the *hind brain* (*h*), forms the so-called *little hemispheres*, together with the middle part of the *small brain* (cerebellum), a part of the brain as to the function of which the most contradictory conjectures are entertained, but which seems principally to regulate the co-ordination of movements. Lastly, the *fifth* bladder, the *after brain* (*n*), develops into that very important part of the central nervous system which is called the *prolonged marrow* (medulla oblongata). It is the central organ of the respiratory movements, and of other important functions, and an injury to it immediately causes death, whereas the large hemispheres of the fore brain (or the organ of the "soul," in a restricted sense) can be removed bit by bit, and even completely destroyed, without causing the death of the vertebrate animal—only its higher mental activities disappearing in consequence.

These five brain bladders, in all vertebrate animals which possess a brain at all, are originally arranged in the same manner and develop gradually in the different groups so differently, that it is afterwards very difficult to recognize the corresponding parts in the fully-developed brains. In the early stage of development which is represented in Fig. 7, it seems as yet quite impossible to distinguish the embryos of the different mammals, birds, and reptiles, from one another. But if we compare the much more developed embryos on Plates II. and III. with one another, we can clearly see an inequality in their development, and especially it will be perceived that the brain of the two mammals (*G* and *H*) already strongly differ from that of birds (*F*) and of reptiles (*E*). In the two latter the mid brain predominates, but in the former the fore brain. Even at this stage the

brain of the bird (*F*) is scarcely distinguishable from that of the tortoise (*E*), and in like manner the brain of the dog (*G*) is as yet almost the same as that of man (*H*). If, on the other hand, we compare the brains of these four vertebrate animals in a fully developed condition, we find them so very different in all anatomical particulars, that we cannot doubt for a moment as to which animal each brain belongs.

I have here explained the original equality, the gradual commencement, and the ever increasing separation or differentiation of the embryos in the different vertebrate animals, taking the brain as a special example, just because this organ of the soul's activity is of special interest. But I might as well have discussed in its stead the heart, or the liver, or the limbs, in short, any other part of the body, since the same wonder of creation is here ever repeated, namely, this, that all parts are originally the same in the different vertebrate animals, and that the variations by which the different classes, orders, families, genera, etc., differ and deviate from one another, are only gradually developed.

There are certainly few parts of the body which are so differently constructed as the *limbs or extremities* of the vertebrate animals. Now, I wish the reader to compare in Fig. *A—H* on Plates II. and III., the four extremities (*bv*) of the embryos with one another, and he will scarcely be able to perceive any important differences between the human arm (*H bv*), the wing of a bird (*F bv*), the slim foreleg of a dog (*G bv*), and the plump foreleg of the tortoise (*E bv*). In comparing the hinder extremities (*bh*) in these figures he will find it equally difficult to distinguish the leg of a man (*H bh*), of a bird (*F bh*), the hind-leg of a dog (*G bh*), and that of a tortoise (*E bh*). The fore as well as the hinder

Germ or Embryos

Pl. II.

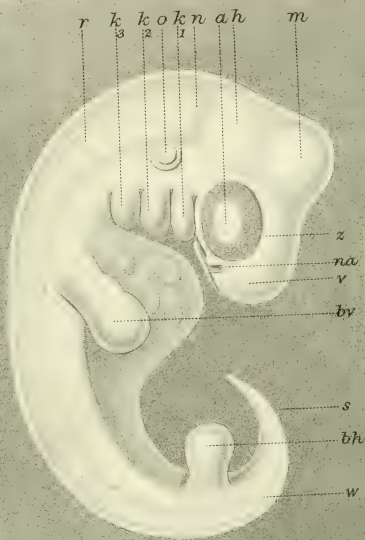


Fig. A.

Tortoise (IV Weeks)

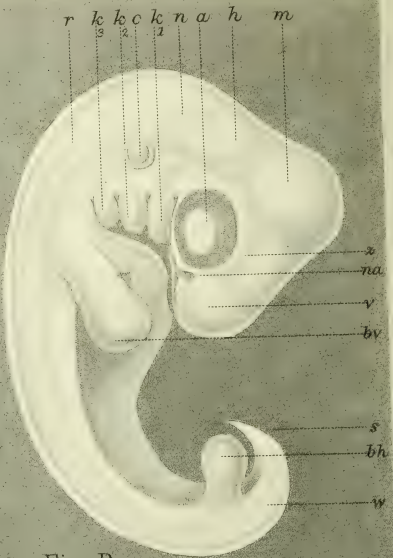


Fig. B.

Chick (IV Days)

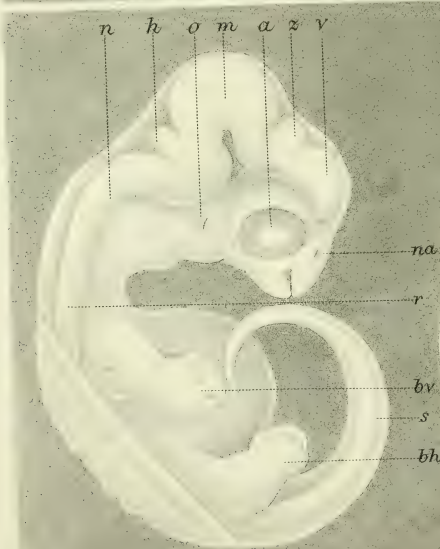


Fig. E.

Tortoise (VI Weeks)

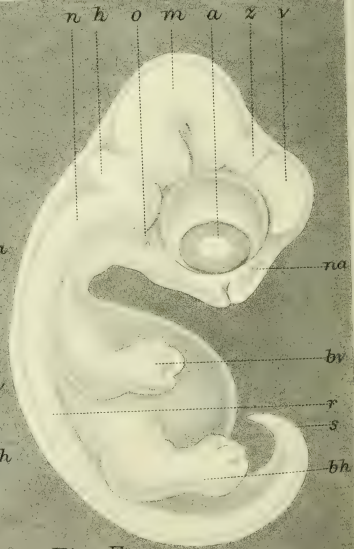
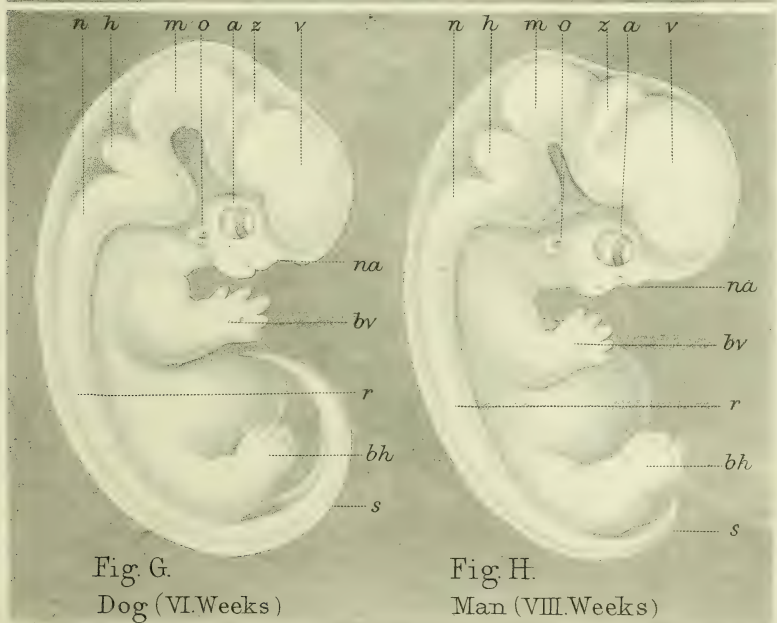
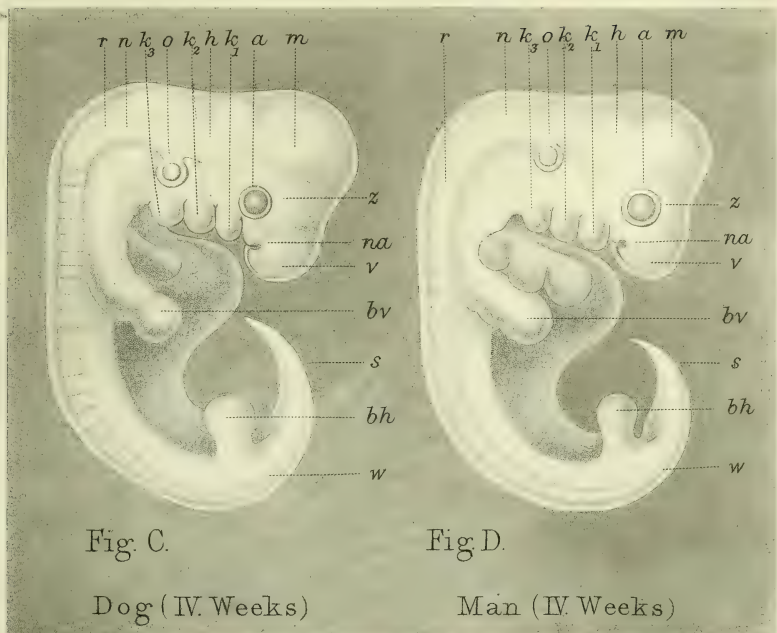


Fig. F.

Chick (VIII Days)

v. Fore-brain, z. Twist-brain, m. Mid-brain, h. Hind-brain,
n. After-brain, w. Spine, r. Spinal-cord.



na . Nose, a . Eyes, o . Ear, k_1 k_2 k_3 . Gill-arches, s . Tail,
 bv . Fore-leg, bh . Hind-leg.

extremities are as yet short, broad lumps, at the ends of which the foundations of the five toes are placed, connected as yet by a membrane. At a still earlier stage (Fig. *A—D*) the five toes are not marked out at all, and it is quite impossible to distinguish even the fore and hinder extremities from one another. The latter, as well as the former, are nothing but simple roundish processes, which have grown out of the side of the trunk. At the very early stage represented in Fig. 7 they are completely wanting, and the whole embryo is a simple trunk without a trace of limbs.

I wish especially to draw attention in Plates II. and III., which represents embryos in early stages of development (Fig. *A—D*)—and in which we are not able to recognize a trace of the full-grown animal—to an exceedingly important formation, which originally is common to all vertebrate animals, but which at a later period is transformed into the most different organs. Every one surely knows the *gill-arches* of fish, those arched bones which lie behind one another, to the number of three or four, on each side of the neck, and which support the gills, the respiratory organs of the fish (double rows of red leaves, which are popularly called “fishes’ ears.”) Now, these gill-arches originally exist exactly the same in man (*D*), in dogs (*C*), in fowls (*B*), and in tortoises (*A*), as well as in all other vertebrate animals. (In Fig. *A—D* the three gill-arches of the right side of the neck are marked k_1 k_2 k_3). Now, it is only in fishes that these remain in their original form, and develop into respiratory organs. In the other vertebrate animals they are partly employed in the formation of the face (especially the jaw apparatus), and partly in the formation of the organ of hearing.

Finally, when comparing the embryos on Plates II. and III., we must not fail to give attention again to the *human tail* (*s*), an organ which, in the original condition, man shares with all other vertebrate animals. The discovery of tailed men was long anxiously expected by many monistic philosophers, in order to establish a closer relationship between man and the other mammals. And in like manner their dualistic opponents often maintained with pride that the complete want of a tail formed one of the most important bodily distinctions between men and animals, though they did not bear in mind the many tailless animals which really exist. Now, man in the first months of development possesses a real tail as well as his nearest kindred, the tailless apes (orang-outang, chimpanzee, gorilla), and vertebrate animals in general. But whereas, in most of them—for example, the dog (*C, G*)—in the course of development it always grows longer, in man (*Fig. D, H*) and in tailless mammals, at a certain period of development, it degenerates and finally completely disappears. However, even in fully developed men, the remnant of the tail is seen in the three, four, or five tail vertebræ (vertebræ coccygeæ) as an aborted or rudimentary organ, which forms the hinder or lower end of the vertebral column (p. 289).

Most persons even now refuse to acknowledge the most important deduction of the Theory of Descent, that is, the palæontological development of man from ape-like, and through them from still lower, mammals, and consider such a transformation of organic form as impossible. But, I ask, are the phenomena of the individual development of man, the fundamental features of which I have here given, in any way less wonderful? Is it not in the highest

degree remarkable that all vertebrate animals of the most different classes—fishes, amphibious animals, reptiles, birds, and mammals—in the first periods of their embryonic development cannot be distinguished at all, and even much later, at a time when reptiles and birds are already distinctly different from mammals, that the dog and the man are almost identical? Verily, if we compare those two series of development with one another, and ask ourselves which of the two is the more wonderful, it must be confessed that *ontogeny*, or the short and quick history of development of the *individual*, is much more mysterious than *phylogeny*, or the long and slow history of development of the *tribe*. For one and the same grand change of form is accomplished by the latter in the course of many thousands of years, and by the former in the course of a few months. Evidently this most rapid and astonishing transformation of the individual in ontogenesis, which we can actually point out at any moment by direct observation, is in itself much more wonderful and astonishing than the corresponding, but much slower and gradual transformation which the long chain of ancestors of the same individual has gone through in phylogenesis.

The two series of organic development, the ontogenesis of the individual and the phylogenesis of the tribe to which it belongs, stand in the closest causal connection with each other. I have endeavoured, in the second volume of the "General Morphology,"⁴ to establish this theory in detail, as I consider it exceedingly important. As I have there shown, *ontogenesis, or the development of the individual, is a short and quick repetition (recapitulation) of phylogenesis, or the development of the tribe to which it belongs, determined*

by the laws of inheritance and adaptation ; by tribe I mean the ancestors which form the chain of progenitors of the individual concerned. (Gen. Morph. ii. p. 110-147, 371.)

In this intimate connection of ontogeny and phylogeny, I see one of the most important and irrefutable proofs of the Theory of Descent. No one can explain these phenomena unless he has recourse to the laws of Inheritance and Adaptation ; by these alone are they explicable. These laws, which we have previously explained, are *the laws of abbreviated, of homochronic, and of homotopic inheritance*, and here deserve renewed consideration. As so high and complicated an organism as that of man, or the organism of every other mammal, rises upwards from a simple cellular state, and as it progresses in its differentiation and perfecting it passes through the same series of transformations which its animal progenitors have passed through, during immense spaces of time, inconceivable ages ago. I have already pointed out this extremely important parallelism of the development of individuals and tribes (p. 10). Certain very early and low stages in the development of man, and the other vertebrate animals in general, correspond completely in many points of structure with conditions which last for life in the lower fishes. The next phase which follows upon this presents us with a change of the fish-like being into a kind of amphibious animal. At a later period the mammal, with its special characteristics, develops out of the amphibian, and we can clearly see, in the successive stages of its later development, a series of steps of progressive transformation which evidently correspond with the differences of different mammalian orders and families. Now, it is precisely in the same succession that we also see

the ancestors of man, and of the higher mammals, appear one after the other in the earth's history; first fishes, then amphibians, later the lower, and at last the higher mammals. Here, therefore, the embryonic development of the individual is completely parallel to the palæontological development of the whole tribe to which it belongs, and this exceedingly interesting and important phenomenon can be explained only by the interaction of the laws of Inheritance and Adaptation.

The example last mentioned, of the parallelism of the palæontological and of the individual developmental series, now directs our attention to a third developmental series, which stands in the closest relations to these two, and which likewise runs, on the whole, parallel to them. I mean that series of development of forms which constitutes the object of investigation in *comparative anatomy*, and which I will briefly call the *systematic developmental series of species*. By this we understand the chain of the different, but related and connected forms, which exist *side by side* at any one period of the earth's history; as for example, at the present moment. While comparative anatomy compares the different forms of fully-developed organisms with one another, it endeavours to discover the common prototypes which underlie, as it were, the manifold forms of kindred genera, classes, etc., and which are more or less concealed by their particular differentiation. It endeavours to make out the series of progressive steps which are indicated in the different degrees of perfection of the divergent branches of the tribe. To make use again of the same particular instance, comparative anatomy shows us how the individual organs and systems of organs in the tribe of vertebrate

animals—in the different classes, families, and species of it—have unequally developed, differentiated, and perfected themselves. It shows us how far the succession of classes of vertebrate animals, from the Fishes upwards, through the Amphibia to the Mammals, and here again, from the lower to the higher orders of Mammals, forms a progressive series or ladder. This attempt to establish a connected anatomical developmental series we may discover in the works of the great comparative anatomists of all ages—in the works of Goethe, Meckel, Cuvier, Johannes Müller, Gegenbaur, and Huxley.

The developmental series of mature forms, which comparative anatomy points out in the different diverging and ascending steps of the organic system, and which we call the systematic developmental series, is parallel to the palæontological developmental series, because it deals with the *result* of palæontolglcal development, and it is parallel to the individual developmental series, because this is parallel to the palæontological series. If two parallels are parallel to a third, they must be parallel to one another.

The varied differentiation, and the unequal degree of perfecting which comparative anatomy points out in the developmental series of the System, is chiefly determined by the ever increasing variety of conditions of existence to which the different groups adapt themselves in the struggle for life, and by the different degrees of rapidity and completeness with which this adaptation has been effected. Conservative groups which have retained their inherited peculiarities most tenaciously remain, in consequence, at the lowest and rudest stage of development. Those groups progressing most rapidly and variously, and which have adapted

themselves to changed conditions of existence most readily have attained the highest degree of perfection. The further the organic world developed in the course of the earth's history, the greater must the gap between the lower conservative and the higher progressive groups have become, as in fact may be seen too in the history of nations. In this way also is explained the historical fact, that the most perfect animal and vegetable groups have developed themselves in a comparatively short time to a considerable height, while the lowest or most conservative groups have remained stationary throughout all ages in their original simple stage, or have progressed, but very slowly and gradually. The series of man's progenitors clearly shows this state of things. The sharks of the present day are still very like the primary fish, which are among the most ancient vertebrate progenitors of man, and the lowest amphibians of the present day (the gilled salamanders and salamanders) are very like the amphibians which first developed themselves out of fishes. So, too, the later ancestors of man, the Monotremata and Marsupials, the most ancient mammals, are at the same time the most imperfect animals of the class which still exist.

The laws of inheritance and adaptation known to us are completely sufficient to explain this exceedingly important and interesting phenomenon, which may be briefly designated as the *parallelism of individual, of palæontological, and of systematic development*. No opponent of the Theory of Descent has been able to give an explanation of this extremely wonderful fact, whereas it is perfectly explained, according to the Theory of Descent, by the laws of Inheritance and Adaptation.

If we examine this parallelism of the three organic series of development more accurately, we have to add the following special qualifications. *Ontogeny*, or the history of the individual development of every organism (embryology and metamorphology), presents us with a simple *unbranching* or graduated chain of forms; and so it is with that *portion of phylogeny* which comprises the palæontological history of development of the *direct ancestors only* of an individual organism. But *the whole of phylogeny*—which meets us in the *natural system* of every organic tribe or phylum, and which is concerned with the investigation of the palæontological development of *all* the branches of this tribe—forms a *branching* or tree-shaped developmental series, a veritable pedigree. If we examine and compare the branches of this pedigree, and place them together according to the degree of their differentiation and perfection, we obtain the tree-shaped, branching, *systematic developmental series of comparative anatomy*. Strictly speaking, therefore, the latter is parallel to *the whole of phylogeny*, and consequently is only partially parallel to ontogeny; for ontogeny itself is parallel only to *a portion* of phylogeny.

All the phenomena of organic development above discussed, especially the threefold genealogical parallelism, and the laws of differentiation and progress, which are evident in each of these three series of organic development, and, further, the whole history of rudimentary organs, are exceedingly important proofs of the truth of the Theory of Descent. For by it alone can they be explained, whereas its opponents cannot even offer a shadow of an explanation of them. Without the Doctrine of Filiation, the fact of

organic development in general cannot be understood. We should therefore, for this reason alone, be forced to accept Lamarck's Theory of Descent, even if we did not possess Darwin's Theory of Selection.

CHAPTER XIII.

THEORY OF THE DEVELOPMENT OF THE UNIVERSE
AND OF THE EARTH. SPONTANEOUS GENERA-
TION. THE CARBON THEORY. THE PLASTID
THEORY.

History of the Development of the Earth.—Kant's Theory of the Development of the Universe, or the Cosmological Gas Theory.—Development of Suns, Planets, and Moons.—First Origin of Water.—Comparison of Organisms and Anorgana.—Organic and Inorganic Substances.—Degrees of Density, or Conditions of Aggregation.—Albuminous Combinations of Carbon.—Organic and Inorganic Forms.—Crystals and Formless Organisms without Organs.—Stereometrical Fundamental Forms of Crystals and of Organisms.—Organic and Inorganic Forces.—Vital Force.—Growth and Adaptation in Crystals and in Organisms.—Formative Tendencies of Crystals.—Unity of Organic and Inorganic Nature.—Spontaneous Generation, or Archigony.—Autogony and Plasmogony.—Origin of Monera by Spontaneous Generation.—Origin of Cells from Monera.—The Cell Theory.—The Plastid Theory.—Plastids, or Structural-Units.—Cytods and Cells.—Four Different Kinds of Plastids.

IN our considerations hitherto we have endeavoured to answer the question, "By what causes have new species of animals and plants arisen out of existing species?" We have answered this question according to Darwin's theory, that natural selection in the struggle for existence—that is, the interaction of the laws of Inheritance and Adaptation—is completely sufficient for producing mechanically the

endless variety of the different animals and plants, which have the appearance of being organized according to a plan for a definite purpose. Meanwhile the question must have already repeatedly presented itself to the reader, how did the first organisms, or that one original and primæval organism arise, from which we derive all the others ?

This question Lamarck ² answered by the hypothesis of *spontaneous generation*, or *archigony*. But Darwin passes over and avoids this subject, as he expressly remarks that he has "nothing to do with the origin of the soul, nor with that of life itself." At the conclusion of his work he expresses himself more distinctly in the following words :—" I imagine that probably all organic beings which ever lived on this earth descended from some primitive form, which was first called into life by the Creator." Moreover, Darwin, for the consolation of those who see in the Theory of Descent the destruction of the whole "moral order of the universe," appeals to the celebrated author and divine who wrote to him, that "he has gradually learnt to see that it is just as noble a conception of the Deity to believe that he created a few original forms capable of self-development into other and needful forms, as to believe that he required a fresh act of creation to supply the voids caused by the action of his laws."

Those to whom the belief in a supernatural creation is an emotional necessity may rest satisfied with this conception. They may reconcile that belief with the Theory of Descent ; for in the creation of a single original organism possessing the capability to develop all others out of itself by inheritance and adaptation, they can really find much more cause

for admiring the power and wisdom of the Creator than in the independent creation of different species.

If, taking this point of view, we were to explain the origin of the first terrestrial organisms, from which all the others are descended, as due to the action of a personal Creator acting according to a definite plan, we should of course have to renounce all scientific knowledge of the process, and pass from the domain of true science to the completely distinct domain of poetical faith. By assuming a supernatural act of creation we should be taking a leap into the inconceivable. Before we decide upon this latter step, and thereby renounce all pretension to a scientific knowledge of the process, we are at all events in duty bound to endeavour to examine it in the light of a mechanical hypothesis. We must at least examine whether this process is really so wonderful, and whether we cannot form a tenable conception of a completely non-miraculous origin of the first primary organism. We might then be able entirely to reject miracle in creation.

It will be necessary for this purpose, first of all, to go back further into the past, and to examine the history of the creation of the earth. Going back still further, we shall find it necessary to consider the history of the creation of the whole universe in its most general outlines. All my readers undoubtedly know that from the structure of the earth, as it is at present known to us, the notion has been derived, and as yet has not been refuted, that its interior is in a fiery fluid condition, and that the firm crust, composed of different strata, on the surface of which organisms are living, forms only a very thin pellicle or shell round the fiery fluid centre. We have

arrived at this idea by different confirmatory experiments and reasonings. In the first place, the observation that the temperature of the earth's crust continually increases towards the centre is in favour of this supposition. The deeper we descend, the greater the warmth of the ground, and in such proportion, that with every 100 feet the temperature increases about one degree. At a depth of six miles, therefore, a heat of 1500° would be attained, sufficient to keep most of the firm substances of our earth's crust in a molten, fiery, fluid state. This depth, however, is only the 286th part of the whole diameter of the earth (1717 miles). We further know that springs which rise out of a considerable depth possess a very high temperature, and sometimes even throw water up to the surface in a boiling state. Lastly, very important proofs are furnished by volcanic phenomena, the eruption of fiery fluid masses of stone bursting through certain parts of the earth's crust. All these phenomena lead us with great certainty to the important assumption that the firm crust of the earth forms only quite 'a small fraction, not nearly the one-thousandth part of the whole diameter of the terrestrial globe, and that the rest is still for the most part in a molten or fiery fluid state.

Now if, starting with this assumption, we reflect on the ancient history of the development of the globe, we are logically carried back a step further, namely, to the assumption that at an earlier date the whole earth was a fiery fluid body, and that the formation of a thin, stiffened crust on the surface was only a later process. Only gradually, by radiating its intrinsic heat into the cold space of the universe, has the surface of the glowing ball become condensed into

a thin crust. That the temperature of the earth in remote times was much higher than it is now, is proved by many phenomena. Among other things, this is rendered probable by the equal distribution of organisms in remote times of the earth's history. While at present, as is well known, the different populations of animals and plants correspond to the different zones of the earth and their appropriate temperature, in earlier times this was distinctly not the case.

We see from the distribution of fossils in the remoter ages, that it was only at a very late date, in fact, at a comparatively recent period of the organic history of the earth (at the beginning of the so-called cænolithic or tertiary period), that a separation of zones and of the corresponding organic populations occurred. During the immensely long primary and secondary periods, tropical plants, which require a very high degree of temperature, lived not only in the present torrid zone, under the equator, but also in the present temperate and frigid zones. Many other phenomena also demonstrate a gradual decrease of the temperature of the globe as a whole, and especially a late and gradual cooling of the earth's crust about the poles. Bronn, in his excellent "Investigations of the Laws of Development of the Organic World," has collected numerous geological and palæontological proofs of this fact.

These phenomena and the mathematico-astronomical knowledge of the structure of the universe justify the theory that, inconceivable ages ago, long before the first existence of organisms, the whole earth was a fiery fluid globe. Now, this theory corresponds with the grand theory of the origin of the universe, and especially of our planetary system, which,

on the ground of mathematical and astronomical facts, was put forward in 1755 by our critical philosopher Kant,²² and was later more thoroughly established by the celebrated mathematicians, Laplace and Herschel. This cosmogeny, or theory of the development of the universe, is now almost universally acknowledged; it has not been replaced by a better one, and mathematicians, astronomers, and geologists have continually, by various arguments, strengthened its position.

Kant's cosmogeny maintains that *the whole universe, inconceivable ages ago, consisted of a gaseous chaos*. All the substances which are found at present separated on the earth, and other bodies of the universe, in different conditions of density—in the solid, semi-fluid, liquid, and elastic fluid or gaseous states of aggregation—originally constituted together one single homogeneous mass, equally filling up the space of the universe, which, in consequence of an extremely high degree of temperature, was in an exceedingly thin gaseous or nebulous state. The millions of bodies in the universe which at present form the different solar systems did not then exist. They originated only in consequence of a universal rotatory movement, or rotation, during which a number of masses acquired greater density than the remaining gaseous mass, and then acted upon the latter as central points of attraction. Thus arose a separation of the chaotic primary nebula, or gaseous universe, into a number of rotating nebulous spheres, which became more and more condensed. Our solar system was such a gigantic gaseous or nebulous ball, all the particles of which revolved round a common central point, the solar nucleus. The nebulous ball itself, like all the rest, in consequence

of its rotatory movement, assumed a spheroidal or a flattened globular form.

While the centripetal force attracted the rotating particles nearer and nearer to the firm central point of the nebulous ball, and thus condensed the latter more and more, the centrifugal force, on the other hand, always tended to separate the peripheral particles further and further from it, and to hurl them off. On the equatorial sides of the ball, which was flattened at both poles, this centrifugal force was strongest, and as soon as, by increase of density, it attained predominance over the centripetal force, a circular nebulous ring separated itself from the rotating ball. This nebulous ring marked the course of future planets. The nebulous mass of the ring gradually condensed, and became a planet, which revolved round its own axis, and at the same time rotated round the central body. In precisely the same manner, from the equator of the planetary mass, as soon as the centrifugal force gained predominance over the centripetal force, new nebulous rings were ejected, which moved round the planets as the latter moved round the sun. These nebulous rings, too, became condensed into rotating balls. Thus arose the moons, only one of which moves round our earth, whilst four move round Jupiter, and six round Uranus. The ring of Saturn still shows us a moon in its early stage of development. As by increasing refrigeration these simple processes of condensation and expulsion repeated themselves over and over again, there arose the different solar systems, the planets rotating round their central suns, and the satellites or moons moving round their planets.

The original gaseous condition of the rotating bodies of

the universe gradually changed, by increasing refrigeration and condensation, into the fiery fluid or molten state of aggregation. By the process of condensation, a great quantity of heat was emitted, and the rotating suns, planets, and moons, soon changed into glowing balls of fire, like gigantic drops of melted metal, which emitted light and heat. By loss of heat, the melted mass on the surface of the fiery fluid ball became further condensed, and thus arose a thin, firm crust, which enclosed a fiery fluid nucleus. In all essential respects our mother earth probably did not differ from the other bodies of the universe.

In view of the object of these pages, it will not be of especial interest to follow in detail the *history of the natural creation of the universe*, with its different solar and planetary systems, and to establish it mathematically by the different astronomical and geological proofs. The outlines of it, which I have just mentioned, must be sufficient here, and for further details I refer to Kant's* "*General History of Nature and Theory of the Heavens.*"²² I will only add that this wonderful theory, which might be called *the cosmological gas theory*, harmonizes with all the general series of phenomena at present known to us, and stands in no irreconcilable contradiction to any one of them. Moreover, it is purely mechanical or monistic, makes use exclusively of the inherent forces of eternal matter, and entirely excludes every supernatural process, every prearranged and conscious action of a personal Creator. Kant's Cosmological Gas Theory consequently occupies a similar supreme position in *Anorganology*, especially in *Geology*, and forms the crown of our knowledge in that department, in the same

* "*Allgemeine Naturgeschichte und Theorie des Himmels*"

way as Lamarck's Theory of Descent does in *Biology*, and especially in *Anthropology*. Both rest exclusively upon mechanical or unconscious causes (*causæ efficientes*), in no case upon prearranged or conscious causes (*causæ finales*). (Compare above, p. 100-106). Both therefore fulfil all the demands of a scientific theory, and consequently will remain generally acknowledged until they are replaced by better ones.

I will, however, not deny that Kant's grand cosmogeny has some weak points, which prevent our placing the same unconditional confidence in it as in Lamarck's Theory of Descent. The notion of an original gaseous chaos filling the whole universe presents great difficulties of various kinds. A great and unsolved difficulty lies in the fact that the Cosmological Gas Theory furnishes no starting-point at all in explanation of the first impulse which caused the rotary motion in the gas-filled universe. In seeking for such an impulse, we are involuntarily led to the mistaken questioning about a "first beginning." We can as little imagine a *first beginning* of the eternal phenomena of the motion of the universe as of its final end.

The universe is unlimited and immeasurable in both space and time. It is eternal, and it is infinite. Nor can we imagine a beginning or end to the uninterrupted and eternal motion in which all particles of the universe are always engaged. The great laws of the *conservation of force* ³⁸ and the *conservation of matter*, the foundations of our whole conception of nature, admit of no other supposition. The universe, as far as it is cognisable to human capability, appears as a connected chain of material phenomena of motion, necessitating a continual change of

forms. Every form, as the temporary result of a multiplicity of phenomena of motion, is as such perishable, and of limited duration. But, in the continual change of forms, matter and the motion inseparable from it remain eternal and indestructible.

Now, although Kant's Cosmological Gas Theory is not able to explain the development of motion in the whole universe in a satisfactory manner, beyond that gaseous state of chaos, and although many other weighty considerations may be brought forward against it, especially by chemistry and geology, yet we must on the whole acknowledge its great merit, inasmuch as it explains in an excellent manner, by due consideration of development, the whole structure of all that is accessible to our observation, that is, the anatomy of the solar systems, and especially of our planetary system. It may be that this development was altogether different from what Kant supposes, and our earth may have arisen by the aggregation of numberless small meteorides, scattered in space, or in any other manner, but hitherto no one has as yet been able to establish any other theory of development, or to offer one in the place of Kant's cosmogeny.

After this general glance at the monistic cosmogeny, or the non-miraculous history of the development of the universe, let us now return to a minute fraction of it, to our mother earth, which we left as a ball flattened at both poles and in a fiery fluid state, its surface having condensed by becoming cooled into a very thin firm crust. The crust, on first cooling, must have covered the whole surface of the terrestrial sphere as a continuous smooth and thin shell. But soon it must have become uneven and hummocky ; for,

since during the continued cooling, the fiery fluid nucleus became more and more condensed and contracted, and consequently the diameter of the earth diminished, the thin cold crust, which could not closely follow the softer nuclear mass, must have fallen in, in many places. An empty space would have arisen between the two, had not the pressure of the outer atmosphere forced down the fragile crust towards the interior, breaking it in so doing. Other unevennesses probably arose from the fact that, in different parts, the cooled crust during the process of refrigeration contracted also itself, and thus became fissured with cracks and rents. The fiery fluid nucleus flowed up to the external surface through these cracks, and again became cooled and stiff. Thus, even at an early period there arose many elevations and depressions, which were the first foundations of mountains and valleys.

After the temperature of the cooled terrestrial ball had fallen to a certain degree, a very important new process was effected, namely, the *first origin of water*. Water had until then existed only in the form of steam in the atmosphere surrounding the globe. The water could evidently not condense into a state of fluid drops until the temperature of the atmosphere had considerably decreased. Now, then, there began a further transformation of the earth's crust by the force of water. It continually fell in the form of rain, and in that form washed down the elevations of the earth's crust, filling the depressions with the mud carried along, and, by depositing it in layers, it caused the extremely important neptunic transformations of the earth's crust, which have continued since then uninterruptedly, and which in our next chapter we shall examine a little more closely.

It was not till the earth's crust had so far cooled that the water had condensed into a fluid form, it was not till the hitherto dry crust of the earth had for the first time become covered with liquid water, that the origin of the first organisms could take place. For all animals and all plants—in fact, all organisms—consist in great measure of fluid water, which combines in a peculiar manner with other substances, and brings them into a semi-fluid state of aggregation. We can therefore, from these general outlines of the inorganic history of the earth's crust, deduce the important fact, that at a certain definite time life had its beginning on earth, and that terrestrial organisms did not exist from eternity, but at a certain period came into existence for the first time.

Now, how are we to conceive of this origin of the first organisms? This is the point at which most naturalists, even at the present day, are inclined to give up the attempt at natural explanation, and take refuge in the miracle of an inconceivable creation. In doing so, as has already been remarked, they quit the domain of scientific knowledge, and renounce all further insight into the eternal laws which have determined nature's history. But before despondingly taking such a step, and before we despair of the possibility of any knowledge of this important process, we may at least make an attempt to understand it. Let us see if in reality the origin of a first organism out of inorganic matter, the origin of a living body out of lifeless matter, is so utterly inconceivable, and beyond all experience. In one word, let us examine the question of *spontaneous generation*, or *archigony*. In so doing, it is above all things necessary to form a clear idea of the principal properties of the two chief

groups of natural bodies, the so-called inanimate or inorganic, and the animate or organic bodies, and then establish what is common to, and what are the differences between, the two groups. It is desirable to go somewhat carefully into the *comparison of organisms and anorgana*, since it is commonly very much neglected, although it is necessary for a right understanding of nature from the monistic point of view. It will be most advantageous here to look separately at the three fundamental properties of every natural body; these are matter, form, and force. Let us begin with *matter*. (Gen. Morph. iii.)

By chemistry we have succeeded in analysing all bodies known to us into a small number of elements or simple substances, which cannot be further divided, for example, carbon, oxygen, nitrogen, sulphur, and the different metals: potassium, sodium, iron, gold, etc. At present we know about seventy such elements or simple substances. The majority of them are unimportant and rare; the minority only are widely distributed, and compose not only most of the anorgana, but also all organisms. If we compare those elements which constitute the body of organisms with those which are met with in anorgana, we have first to note the highly important fact that in animal and vegetable bodies no element occurs but what can be found outside of them in inanimate nature. There are no special organic elements or simple organic substances.

The chemical and physical differences existing between organisms and anorgana, consequently, do not lie in their material foundation; they do not arise from the different nature of the *elements* composing them, but from the different manner in which the latter are united by chemical

combination. This different manner of combination gives rise to certain physical peculiarities, especially in density of substance, which at first sight seems to constitute a deep chasm between the two groups of bodies. Inorganic or inanimate natural bodies, such as crystals and the amorphous rocks, are in a state of density which we call the firm or solid state, and which we oppose to the liquid state of water and to the gaseous state of air. It is familiar to every one that these three different degrees of density, or states of aggregation of anorgana, are by no means peculiar to the different elements, but are the results of a certain degree of temperature. Every inorganic solid body, by increase of temperature, can be reduced to the liquid or melted state, and, by further heat, to the gaseous or elastic state. In the same way most gaseous bodies, by a proper decrease of temperature can first be converted into a liquid state, and further, into a solid state of density.

In opposition to these three states of density of anorgana, the living body of all organisms—animals as well as plants—is in an altogether peculiar fourth state of aggregation. It is neither solid like stone, nor liquid like water, but presents rather a medium between these two states, which may therefore be designated as the firm-fluid or swollen state of aggregation (*viscid*). In all living bodies, without exception, there is a certain quantity of water combined in a peculiar way with solid matter, and owing to this characteristic combination of water with solid matter we have that soft state of aggregation, neither solid nor liquid, which is of great importance in the mechanical explanation of the phenomena of life. Its cause lies essentially in the physical and chemical properties of a simple, indivisible,

elementary substance, namely, *carbon* (Gen. Morph. i. 122-130).

Of all elements, carbon is to us by far the most important and interesting, because this simple substance plays the largest part in all animal and vegetable bodies known to us. It is that element which, by its peculiar tendency to form complicated combinations with the other elements, produces the greatest variety of chemical compounds, and among them the forms and living substance of animal and vegetable bodies. Carbon is especially distinguished by the fact that it can unite with the other elements in infinitely manifold relations of number and weight. By the combination of carbon with three other elements, with oxygen, hydrogen, and nitrogen (to which generally sulphur, and frequently, also, phosphorus is added), there arise those exceedingly important compounds which we have become acquainted with as the first and most indispensable substratum of all vital phenomena, the albuminous combinations, or albuminous bodies (protean matter).

We have before this (p. 185) become acquainted with the simplest of all species of organisms in the Monera, whose entire bodies when completely developed consist of nothing but a semi-fluid albuminous lump; they are organisms which are of the utmost importance for the theory of the first origin of life. But most other organisms, also, at a certain period of their existence—at least, in the first period of their life—in the shape of egg-cells or germ-cells, are essentially nothing but simple little lumps of such albuminous formative matter, known as plasma, or protoplasma. They then differ from the Monera only by the fact that in the interior of the albuminous corpuscle the cell-kernel, or nucleus, has

separated itself from the surrounding cell-substance (protoplasma). As we have already pointed out, the cells, with their simple attributes, are so many citizens, who by co-operation and differentiation build up the body of even the most perfect organism; this being, as it were, a cell republic (p. 301). The fully developed form and the vital phenomena of such an organism are determined solely by the activities of these small albuminous corpuscles.

It may be considered as one of the greatest triumphs of recent biology, especially of the theory of tissues, that we are now able to trace the wonder of the phenomena of life to these substances, and that we can demonstrate the *infinitely manifold and complicated physical and chemical properties of the albuminous bodies to be the real cause of organic or vital phenomena*. All the different forms of organisms are simply and directly the result of the combination of the different forms of cells. The infinitely manifold varieties of form, size, and combination of the cells have arisen only gradually by the division of labour, and by the gradual adaptation of the simple homogeneous lumps of plasma, which originally were the only constituents of the cell-mass. From this it follows of necessity that the fundamental phenomena of life—nutrition and generation—in their highest manifestations, as well as in their simplest expressions, must also be traced to the material nature of that albuminous formative substance. The other vital activities are gradually evolved from these two. Thus, then, the general explanation of life is now no more difficult to us than the explanation of the physical properties of inorganic bodies. All vital phenomena and formative processes of organisms are as directly dependent upon the

chemical composition and the physical forces of organic matter as the vital phenomena of inorganic crystals—that is, the process of *their* growth and *their* specific formation—are the direct results of their chemical composition and of their physical condition. The *ultimate causes*, it is true, remain in *both* cases concealed from us. When gold and copper crystallize in a cubical, bismuth and antimony in a hexagonal, iodine and sulphur in a rhombic form of crystal, the occurrence is in reality neither more nor less mysterious to us than is every elementary process of organic formation, every self-formation of the organic cell. In this respect we can no longer draw a fundamental distinction between organisms and anorgana, a distinction of which, formerly, naturalists were generally convinced.

Let us secondly examine the agreements and differences which are presented to us in the *formation* of organic and inorganic natural bodies (Gen. Morph. i. 130). Formerly the simple structure of the latter and the composite structure of the former were looked upon as the principal distinction. The body of all organisms was supposed to consist of dissimilar or heterogeneous parts, of instruments or organs which worked together for the purposes of life. On the other hand, the most perfect anorgana, that is to say, crystals, were supposed to consist entirely of continuous or homogeneous matter. This distinction appears very essential. But it loses all importance through the fact that in late years we have become acquainted with the exceedingly remarkable and important Monera.¹⁵ (Compare above, p. 185). The whole body of these most simple of all organisms—a semi-fluid, formless, and simple lump of albumen—consists, in fact, of only a single chemical combi-

nation, and is as perfectly simple in its structure as any crystal, which consists of a single inorganic combination, for example, of a metallic salt or of a silicate of the earths and alkalies.

As naturalists believed in differences in the inner structure or composition, so they supposed themselves able to find complete differences in the external forms of organisms and anorgana, especially in the mathematically determinable crystalline forms of the latter. Certainly crystallization is pre-eminently a quality of the so-called anorgana. Crystals are limited by plane surfaces, which meet in straight lines and at certain measurable angles. • Animal and vegetable forms, on the contrary, seem at first sight to admit of no such geometrical determination. They are for the most part limited by curved surfaces and crooked lines, which meet at variable angles. But in recent times we have become acquainted, among Radiolaria ²³ and among many other Protista, with a large number of lower organisms, whose body, in the same way as crystals, may be traced to a mathematically determinable fundamental form, and whose form in its whole, as well as in its parts, is bounded by definite geometrically determinable planes and angles. In my general doctrine of *Fundamental Forms, or Promorphology*, I have given detailed proofs of this, and at the same time established a general system of forms, the ideal stereometrical type-forms, which explain the real forms of inorganic crystals, as well as of organic individuals (Gen. Morph. i. 375-574). Moreover, there are also perfectly amorphous organisms, like the Monera, Amœba, etc., which change their forms every moment, and in which we are as little able to point out a definite fundamental form as in

the case of the shapeless or amorphous anorgana, such as non-crystallized stones, deposits, etc. We are consequently unable to find any essential difference in the external forms or the inner structure of anorgana and organisms.

Thirdly, let us turn to the *forces* or the *phenomena of motion* of these two different groups of bodies (Gen. Morph. i. 140). Here we meet with the greatest difficulties. The vital phenomena, known as a rule only in the highly developed organisms, in the more perfect animals and plants, seem there so mysterious, so wonderful, so peculiar, that most persons are decidedly of opinion that in inorganic nature there occurs nothing at all similar, or in the least degree comparable to them. Organisms are for this very reason called animate, and the anorgana, inanimate natural bodies. Hence, even so late as the commencement of the present century, the science which investigates the phenomena of life, namely physiology, retained the erroneous idea that the physical and chemical properties of matter were not sufficient for explaining these phenomena. In our own day, especially during the last ten years, this idea may be regarded as having been completely refuted. In physiology, at least, it has now no place. It now never occurs to a physiologist to consider any of the vital phenomena as the result of a mysterious *vital force*, of an active power working for a definite purpose, standing outside of matter, and, so to speak, taking only the physico-chemical forces into its service. Modern physiology has arrived at the strictly monistic conviction that all of the vital phenomena, and, above all, the two fundamental phenomena of nutrition and propagation are purely physico-chemical processes, and directly dependent

on the material nature of the organism, just as all the physical and chemical qualities of every crystal are determined solely by its material composition. Now, as the elementary substance which determines the peculiar material composition of organisms is carbon, we must ultimately reduce all vital phenomena, and, above all, the two fundamental phenomena of nutrition and propagation to the properties of the carbon. *The peculiar-chemico-physical properties, and especially the semi-fluid state of aggregation, and the easy decomposibility of the exceedingly composite albuminous combinations of carbon, are the mechanical causes of those peculiar phenomena of motion which distinguish organisms from anorgana, and which in a narrow sense are usually called "life."*

In order to understand this "*carbon theory*," which I have established in detail in the second book of my General Morphology, it is necessary, above all things, closely to examine those phenomena of motion which are common to both groups of natural bodies. First among them is the *process of growth*. If we cause any inorganic solution of salt slowly to evaporate, crystals are formed in it, which slowly increase in size during the continued evaporation of the water. This process of growth arises from the fact that new particles continually pass over from the fluid state of aggregation into the solid, and, according to certain laws, deposit themselves upon the firm kernel of the crystal already formed. From such an apposition of particles arise the mathematically definite crystalline shapes. In like manner the growth of organisms takes place by the accession of new particles. The only difference is that in the growth of organisms, in consequence of their semi-fluid state of

aggregation, the newly-added particles penetrate into the interior of the organism (inter-susception), whereas anorgana receive homogeneous matter from without only by apposition or an addition of new particles to the surface. This important difference of growth by inter-susception and by apposition is obviously only the necessary and direct result of the different conditions of density or state of aggregation in organisms and anorgana.

Unfortunately I cannot here follow in detail the various exceedingly interesting parallels and analogies which occur between the formation of the most perfect anorgana, the crystals, and the formation of the simplest organisms, the Monera and their next kindred forms. For this I must refer to a minute comparison of organisms and anorgana, which I have carried out in the fifth chapter of my General Morphology (Gen. Morph. i. 111-160). I have there shown in detail that there exist no complete differences between organic and inorganic natural bodies, neither in respect to form and structure, nor in respect to matter and force; and that the actually existing differences are dependent upon the peculiar nature of the *carbon*; and that there exists no insurmountable chasm between organic and inorganic nature. We can perceive this most important fact very clearly if we examine and compare the origin of the forms in crystals and in the simplest organic individuals. In the formation of crystal individuals, two different counter-acting formative tendencies come into operation. The *inner constructive force*, or the inner formative tendency, which corresponds to the Heredity of organisms, in the case of the crystal is the direct result of its material constitution or of its chemical composition. The form of the crystal, so far as

it is determined by this inner original formative tendency, is the result of the specific and definite way in which the smallest particles of the crystallizing matter unite together in different directions according to law. That independent inner formative force, which is directly inherent in the matter itself, is directly counteracted by a second formative force. The *external constructive force*, or the external formative tendency, may be called Adaptation in crystals as well as in organisms. Every crystal individual during its formation, like every organic individual, must submit and adapt itself to the surrounding influences and conditions of existence of the outer world. In fact, the form and size of every crystal is dependent upon its whole surroundings, for example, upon the vessel in which the crystallization takes place, upon the temperature and the pressure of the air under which the crystal is formed, upon the presence or absence of heterogeneous bodies, etc. Consequently, the form of every single crystal, like the form of every single organism, is the result of the interaction of two opposing factors—the *inner* formative tendency, which is determined by the chemical constitution of the *matter itself*, and of the *external* formative tendency, which is dependent upon the influence of *surrounding* matter. Both these constructive forces interact similarly also in the organism, and, just as in the crystal, are of a purely mechanical nature and directly inherent in the substance of the body. If we designate the growth and the formation of organisms as a process of life, we may with equal reason apply the same term to the developing crystal. The teleological conception of nature, which looks upon organisms as machines of creation arranged for a definite purpose, must logically acknowledge the same also

in regard to the forms of crystals. The differences which exist between the simplest organic individuals and inorganic crystals are determined by the *solid* state of aggregation of the latter, and by the *semi-fluid* state of the former. Beyond that the causes producing form are exactly the same in both. This conviction forces itself upon us most clearly, if we compare the exceedingly remarkable phenomena of growth, adaptation, and the "correlation of parts" of developing crystals with the corresponding phenomena of the origin of the simplest organic individuals (Monera and cells). The analogy between the two is so great that, in reality, no accurate boundary can be drawn. In my General Morphology I have quoted in support of this a number of striking facts (Gen. Morph. i. 146, 156, 158.)

If we vividly picture to ourselves this "*unity of organic and inorganic nature*," this essential agreement of organisms and anorgana in matter, form, and force, and if we bear in mind that we are not able to establish any one fundamental distinction between these two groups of bodies (as was formerly generally assumed), then the question of spontaneous generation will lose a great deal of the difficulty which at first seems to surround it. Then the development of the first organism out of inorganic matter will appear a much more easily conceivable and intelligible process than has hitherto been the case, whilst an artificial absolute barrier between organic or animate, and inorganic or inanimate nature was maintained.

In the question of *spontaneous generation*, or *archigony*, which we can now answer more definitely, it must be borne in mind that by this conception we understand generally the *non-parental generation of an organic individual*, the

origin of an organism independent of a parental or producing organism. It is in this sense that on a former occasion (p. 183) I mentioned spontaneous generation (archigony) as opposed to parental generation or propagation (tocogony). In the latter case the organic individual arises by a greater or less portion of an already existing organism separating itself and growing independently. (Gen. Morph. ii. 32.)

In spontaneous generation, which is often also called original generation (*generatio spontanea, æquivoca, primaria* etc.) we must first distinguish two essentially different kinds, namely, *autogeny* and *plasmogeny*. By *autogeny* we understand the origin of a most simple organic individual in an *inorganic formative fluid*, that is, in a fluid which contains the fundamental substances for the composition of the organism dissolved in simple and loose combinations (for example, carbonic acid, ammonia, binary salts, etc.). On the other hand, we call spontaneous generation *plasmogeny* when the organism arises in an *organic formative fluid*, that is, in a fluid which contains those requisite fundamental substances dissolved in the form of complicated and fluid combinations of carbon (for example, albumen, fat, hydrate of carbon, etc.). (Gen. Morph. i. 174. ii. 33.)

Neither the process of autogeny, nor that of plasmogeny, has yet been directly observed with perfect certainty. In early, and also in more recent times, numerous and interesting experiments have been made as to the possibility or reality of spontaneous generation. Almost all these experiments refer not to autogeny, but to plasmogeny, to the origin of an organism out of already formed organic matter.

It is evident, however, that this latter process is only of subordinate interest for our history of creation. It is much more important for us to solve the question, "Is there such a thing as autogeny? Is it possible that an organism can arise, not out of pre-existing organic, but out of purely inorganic, matter?" Hence we can quietly lay aside all the numerous experiments which refer only to plasmogeny, which have been carried on very zealously during the last ten years, and which for the most part have had a negative result. For even supposing that the reality of plasmogeny were strictly proved, still autogeny would not be explained by it.

The experiments on autogeny have likewise as yet furnished no certain and positive result. Yet we must at the outset most distinctly protest against the notion that these experiments have proved the impossibility of spontaneous generation in general. Most naturalists who have endeavoured to decide this question experimentally, and who, after having employed all possible precautionary measures, under well-ascertained conditions, have seen no organisms come into being, have straightway made the assertion, on the ground of these negative results: "That it is altogether impossible for organisms to come into existence by themselves without parental generation." This hasty and inconsiderate assertion they have supported by the negative results of their experiments, which, after all, could prove nothing except that, under these or those highly artificial circumstances created by the experimenters themselves, no organism was developed. From these experiments, which have been for the most part made under the most unnatural conditions, and in a highly artificial

manner, we can by no means draw the conclusion that spontaneous generation in general is impossible. The impossibility of such a process can, in fact, never be proved. For how can we know that in remote primæval times there did not exist conditions quite different from those at present obtaining, and which may have rendered spontaneous generation possible? Indeed, we can even positively and with full assurance maintain that the general conditions of life in primæval times must have been entirely different from those of the present time. Think only of the fact that the enormous masses of carbon which we now find deposited in the primary coal mountains were first reduced to a solid form by the action of vegetable life, and are the compressed and condensed remains of innumerable vegetable substances, which have accumulated in the course of many millions of years. But at the time when, after the origin of water in a liquid state on the cooled crust of the earth, organisms were first formed by spontaneous generation, those immeasurable quantities of carbon existed in a totally different form, probably for the most part dispersed in the atmosphere in the shape of carbonic acid. The whole composition of the atmosphere was therefore extremely different from the present. Further, as may be inferred upon chemical, physical, and geological grounds, the density and the electrical conditions of the atmosphere were quite different. In like manner the chemical and physical nature of the primæval ocean, which then continuously covered the whole surface of the earth as an uninterrupted watery sheet, was quite peculiar. The temperature, the density, the amount of salt, etc., must have been very different from those of the present ocean. In

any case, therefore, even if we do not know anything more about it, there remains to us the supposition, which can at least not be disputed, that at that time, under conditions quite different from those of to-day, a spontaneous generation, which now is perhaps no longer possible, may have taken place.

But it is necessary to add here that, by the recent progress of chemistry and physiology, the mysterious and miraculous character which at first seems to belong to this much disputed and yet inevitable process of spontaneous generation, has been to a great extent, or almost entirely, destroyed. Not fifty years ago, all chemists maintained that we were unable to produce artificially in our laboratories any complicated combination of carbon, or so-called "organic combination." The mystic "vital force" alone was supposed to be able to produce these combinations. When, therefore, in 1828, Wöhler, in Göttingen, for the first time refuted this dogma, and exhibited pure "organic" urea, obtained in an artificial manner from a purely inorganic body (cyanate of ammonium), it caused the greatest surprise and astonishment. In more recent times, by the progress of synthetic chemistry, we have succeeded in producing in our laboratories a great variety of similar "organic" combinations of carbon, by purely artificial means—for example alcohol, acetic acid, formic acid. Indeed, many exceedingly complicated combinations of carbon are now artificially produced, so that there is every likelihood, sooner or later, of our producing artificially the most complicated, and at the same time the most important of all, namely, the albuminous combinations, or plasma-bodies. By the consideration of this probability, the deep chasm which was

formerly and generally believed to exist between organic and inorganic bodies is almost or entirely removed, and the way is paved for the conception of spontaneous generation.

Of still greater, nay, the very greatest importance to the hypothesis of spontaneous generation are, finally, the exceedingly remarkable *Monera*, those creatures which we have already so frequently mentioned, and which are not only the simplest of all observed organisms, but even the simplest of all imaginable organisms. I have already described these wonderful "*organisms without organs*," when examining the simplest phenomena of propagation and inheritance. We already know seven different genera of these *Monera*, some of which live in fresh water, others in the sea (compare above, p. 184; also Plate I. and its explanation in the Appendix). In a perfectly developed and freely motile state, they one and all present us with nothing but a simple little lump of an albuminous combination of carbon. The individual genera and species differ only a little in the manner of propagation and development, and in the way of taking nourishment. Through the discovery of these organisms, which are of the utmost importance, the supposition of a spontaneous generation loses most of its difficulties. For as all trace of organization—all distinction of heterogeneous parts—is still wanting in them, and as all the vital phenomena are performed by one and the same homogeneous and formless matter, we can easily imagine their origin by spontaneous generation. If this happens through *plasmogeny*, and if plasma capable of life already exists, it then only needs to individualize itself in the same way as the mother liquor of crystals individualizes itself in crystallization. If, on the other hand, the spontaneous generation

of the Monera takes place by true *autogeny*, then it is further requisite that that plasma capable of life, that primæval mucus, should be formed out of simpler combinations of carbon. As we are now able artificially to produce, in our laboratories, combinations of carbon similar to this in the complexity of their constitution, there is absolutely no reason for supposing that there are not conditions in free nature also, in which such combinations could take place. Formerly, when the doctrine of spontaneous generation was advocated, it failed at once to obtain adherents on account of the composite structure of the simplest organisms then known. It is only since we have discovered the exceedingly important Monera, only since we have become acquainted in them with organisms not in any way built up of distinct organs, but which consist solely of a single chemical combination, and yet grow, nourish, and propagate themselves, that this great difficulty has been removed, and the hypothesis of spontaneous generation has gained a degree of probability which entitles it to fill up the gap existing between Kant's cosmogony and Lamarck's Theory of Descent. Even among the Monera at present known there is a species which probably, even now, always comes into existence by spontaneous generation. This is the wonderful *Bathybius Hæckelii*, discovered and described by Huxley. As I have already mentioned (p. 184), this Moneron is found in the greatest depths of the sea, at a depth of between 12,000 and 24,000 feet, where it covers the ground partly as retiform threads and plaits of plasma, partly in the form of larger or smaller irregular lumps of the same material.*

* We must wait for fuller information on the subject of *Bathybius*, at the hands of the naturalists of the *Challenger* expedition, before accepting it finally as a distinct organism.—*Editor*.

Only such homogeneous organisms as are yet not differentiated, and are similar to inorganic crystals in being homogeneously composed of one single substance, could arise by spontaneous generation, and could become the primæval parents of all other organisms. In their further development we have pointed out that the most important process is the formation of a *kernel* or *nucleus* in the simple little lump of albumen. We can conceive this to take place in a purely physical manner, by the condensation of the innermost central part of the albumen. The more solid central mass, which at first gradually shaded off into the peripheral plasma, becomes sharply separated from it, and thus forms an independent, round, albuminous corpuscle, the kernel; and by this process the Moneron becomes a *cell*. Now, it must have become evident from our previous chapters, that the further development of all other organisms out of such a cell presents no difficulty, for every animal and every plant, in the beginning of its individual life, is a simple cell. Man, as well as every other animal, is at first nothing but a simple egg-cell, a single lump of mucus, containing a kernel (p. 297, Fig. 5).

In the same way as the kernel of the organic cell arose in the interior or central mass of the originally homogeneous lump of plasma, by separation, so, too, the first *cell-membrane* was formed on its surface. This simple, but most important process, as has already been remarked, can likewise be explained in a purely physical manner, either as a chemical deposit, or as a physical condensation in the uppermost stratum of the mass, or as a secretion. One of the first processes of adaptation effected by the Moneron originating by spontaneous generation must have been the condensation

of an external crust, which as a protecting covering shut in the softer interior from the hostile influences of the outer world. As soon as, by condensation of the homogeneous Moneron, a cell-kernel arose in the interior and a membrane arose on the surface, all the fundamental parts of the unit were furnished, out of which, by infinitely manifold repetition and combination, as attested by actual observation, the body of higher organisms is constructed.

As has already been mentioned, our whole understanding of an organism rests upon the cell theory established thirty years ago by Schleiden and Schwann. According to it, every organism is either a simple cell or a cell-community, a republic of closely connected cells. All the forms and vital phenomena of every organism are the collective result of the forms and vital phenomena of all the single cells of which it is composed. By the recent progress of the cell theory it has become necessary to give the elementary organisms, that is, the "organic" individuals of the first order, which are usually designated as *cells*, the more general and more suitable name of *form-units*, or *plastids*. Among these form-units we distinguish two main groups, namely, the *cytods* and the genuine cells. The *cytods* are, like the Monera, pieces of plasma without a kernel (p. 186, Fig. 1). *Cells*, on the other hand, are pieces of plasma containing a kernel or nucleus (p. 188, Fig. 2). Each of these two main groups of plastids is again divided into two subordinate groups, according as they possess or do not possess an external covering (skin, shell, or membrane). We may accordingly distinguish the following four grades or species of plastids, namely: 1. *Simple cytods* (p. 186, Fig. 1 A); 2. *Encased cytods*; 3. *Simple cells* (p. 188,

Fig. 2 B); 4. *Encased cells* (p. 188, Fig. 2 A). (Gen. Morph. i. 269-289.)

Concerning the relation of these four forms of plastids to spontaneous generation, the following is the most probable:—1. The *simple cytods* (Gymnocytoidea), naked particles of plasma without kernel, like the still living Monera, are the only plastids which directly come into existence by spontaneous generation. 2. The *enclosed cytods* (Lepocytoidea), particles of plasma without kernel, which are surrounded by a covering (membrane or shell), arose out of the simple cytods either by the condensation of the outer layers of plasma or by the secretion of a covering. 3. The *simple cells* (Gymnocyta), or naked cells, particles of plasma with kernel, but without covering, arose out of the simple cytods by the condensation of the innermost particles of plasma into a kernel, or nucleus, by differentiation of a central kernel and peripheral cell-substance. 4. The *enclosed cells* (Lepocyta), or testaceous cells, particles of plasma with kernel and an outer covering (membrane or shell), arose either out of the enclosed cytods by the formation of a kernel, or out of the simple cells by the formation of a membrane. All the other forms of form-units, or plastids, met with, besides these, have only subsequently arisen out of these four fundamental forms by natural selection, by descent with adaptation, by differentiation and transformation.

By this *theory of plastids*, by deducing all the different forms of plastids, and hence, also, all organisms composed of them, from the Monera, we obtain a simple and natural connection in the whole series of the development of nature. The origin of the first Monera by spontaneous generation

appears to us as a simple and necessary event in the process of the development of the earth. We admit that this process, as long as it is not directly observed or repeated by experiment, remains a pure hypothesis. But I must again say that this hypothesis is indispensable for the consistent completion of the non-miraculous history of creation, that it has absolutely nothing forced or miraculous about it, and that certainly it can never be positively refuted. It must be taken into consideration that the process of spontaneous generation, even if it still took place daily and hourly, would in any case be exceedingly difficult to observe and establish with absolute certainty as such. With regard to the Monera, we find ourselves placed before the following alternative: *either* they are actually directly derived from pre-existing, or "created," most ancient Monera, and in this case they would have had to propagate themselves unchanged for many millions of years, and to have maintained their original form of simple particles of plasma; *or*, the *present* Monera have originated much later in the course of the organic history of the earth, by repeated acts of spontaneous generation, and in this case spontaneous generation may take place now as well as then. The latter supposition has evidently much more probability on its side than the former.

If we do not accept the hypothesis of spontaneous generation, then at this one point of the history of development we must have recourse to the miracle of a *supernatural creation*. The Creator must have created the first organism, or a few first organisms, from which all others are derived, and as such he must have created the simplest Monera, or primæval cytods, and given them the capability

of developing further in a mechanical way. I leave it to each one of my readers to choose between this idea and the hypothesis of spontaneous generation. To me the idea that the Creator should have in this one point arbitrarily interfered with the regular process of development of matter, which in all other cases proceeds entirely without his interposition, seems to be just as unsatisfactory to a believing mind as to a scientific intellect. If, on the other hand, we assume the hypothesis of spontaneous generation for the origin of the first organisms, which in consequence of reasons mentioned above, and especially in consequence of the discovery of the Monera, has lost its former difficulty, then we arrive at the establishment of an uninterrupted natural connection between the development of the earth and the organisms produced on it, and, in this last remaining lurking-place of obscurity, we can proclaim the *unity of all Nature, and the unity of her laws of Development* (Gen. Morph. i. 164).

CHAPTER XIV.

MIGRATION AND DISTRIBUTION OF ORGANISMS.
CHOROLOGY AND THE ICE-PERIOD OF THE EARTH.

Chorological Facts and Causes.—Origin of most Species in one Single Locality: "Centres of Creation."—Distribution by Migration.—Active and Passive Migrations of Animals and Plants.—Means of Transport.—Transport of Germs by Water and by Wind.—Continual Change of the Area of Distribution by Elevations and Depressions of the Ground.—Chorological Importance of Geological Processes.—Influence of the Change of Climate.—Ice or Glacial Period.—Its Importance to Chorology.—Importance of Migrations for the Origin of New Species.—Isolation of Colonists.—Wagner's Law of Migration.—Connection between the Theory of Migration and the Theory of Selection.—Agreement of its Results with the Theory of Descent.

As I have repeatedly said, but cannot too much emphasize, the actual value and invincible strength of the Theory of Descent does not lie in its explaining this or that single phenomenon, but in the fact that it explains *all* biological phenomena, that it makes *all* botanical and zoological series of phenomena intelligible in their relations to one another. Hence every thoughtful investigator is the more firmly and deeply convinced of its truth the more he advances from single biological observations to a general view of the whole domain of animal and vegetable life. Let us now, starting from this comprehensive point of view, survey a biological domain, the varied and complicated

phenomena of which may be explained with remarkable simplicity and clearness by the theory of selection. I mean *Chorology*, or the theory of the *local distribution of organisms over the surface of the earth*. By this I do not only mean the *geographical* distribution of animal and vegetable species over the different parts and provinces of the earth, over continents and islands, seas, and rivers; but also their *topographical* distribution in a *vertical* direction, their ascending to the heights of mountains, and their descending into the depths of the ocean. (Gen. Morph. ii. 286.)

The strange chorological series of phenomena which show the horizontal distribution of organisms over parts of the earth, and their vertical distribution in heights and depths, have long since excited general interest. In recent times Alexander Humboldt³⁹ and Frederick Schouw have especially discussed the geography of plants, and Berghaus and Schmarda the geography of animals, on a large scale. But although these and several other naturalists have in many ways increased our knowledge of the distribution of animal and vegetable forms, and laid open to us a new domain of science, full of wonderful and interesting phenomena, yet Chorology as a whole remained, as far as their labours were concerned, only a desultory knowledge of a mass of individual *facts*. It could not be called a science as long as the *causes* for the explanation of these facts were wanting. These causes were first disclosed by the theory of selection and its doctrine of the *migrations* of animal and vegetable species, and it is only since the works of Darwin and Wallace that we have been able to speak of an independent *science of Chorology*.

If all the phenomena of the geographical and topographical distribution of organisms are examined by themselves, without considering the gradual development of species, and if at the same time, following the customary superstition, the individual species of animals and plants are considered as forms independently created and independent of one another, then there remains nothing for us to do but to gaze at those phenomena as a confused collection of incomprehensible and inexplicable miracles. But as soon as we leave this low stand-point, and rise to the height of the theory of development, by means of the supposition of a blood-relationship between the different species, then all at once a clear light falls upon this strange series of miracles, and we see that all chorological facts can be understood quite simply and clearly by the supposition of a common descent of the species, and their passive and active migrations.

The most important principle from which we must start in chorology, and of the truth of which we are convinced by due examination of the theory of selection, is that, as a rule, every animal and vegetable species has arisen only *once* in the course of time and only in *one* place on the earth—its so-called “centre of creation”—by natural selection. I share this opinion of Darwin’s unconditionally, in respect to the great majority of higher and perfect organisms, and in respect to most animals and plants in which the division of labour, or differentiation of the cells and organs of which they are composed, has attained a certain stage. For it is quite incredible, or could at best only be an exceedingly rare accident, that all the manifold and complicated circumstances—all the different conditions of the struggle for life,

which influence the origin of a new species by natural selection—should have worked together in exactly the same agreement and combination more than once in the earth's history, or should have been active at the same time at several different points of the earth's surface.

On the other hand, I consider it to be very probable that certain exceedingly imperfect organisms of the simplest structure, forms of species of an exceedingly indifferent nature, as, for example, many single-celled Protista, but especially the Monera, the simplest of them all, should have several times or simultaneously arisen in their specific form in several parts of the earth. For the few and very simple conditions by which their specific form was changed in the struggle for life may surely have often been repeated, in the course of time, independently in different parts of the earth. Further, those higher specific forms also, which have not arisen by natural selection, but by *hybridism* (the previously-mentioned hybrid species, pp. 147 and 275), may have repeatedly arisen anew in different localities. As, however, this proportionately small number of organisms does not especially interest us here, we may, in respect of chorology, leave them alone, and need only take into consideration the distribution of the great majority of animal and vegetable species in regard to which the *single origin of every species in a single locality*, in its so-called "central point of creation," can be considered as tolerably certain.

Every animal and vegetable species from the beginning of its existence has possessed the tendency to spread beyond the limited locality of its origin, beyond the boundary of its "centre of creation," or, in other words, beyond its

primæval home, or its natal place. This is a necessary consequence of the relations of population and over-population (pp. 161 and 256). The more an animal or vegetable species increases, the less is its limited natal place sufficient for its sustenance, and the fiercer the struggle for life; the more rapid the *over-population* of the natal spot, the more it leads to *emigration*. These *migrations* are common to all organisms, and are the real cause of the wide distribution of the different species of organisms over the earth's surface. Just as men leave over-crowded states, so all animals and plants migrate from their over-crowded primæval homes.

Many distinguished naturalists, especially Lyell¹¹ and Schleiden, have before this repeatedly drawn attention to the great importance of these very interesting migrations of organisms. The means of transport by which they are effected are extremely varied. Darwin has discussed these most excellently in the eleventh and twelfth chapters of his work, which are exclusively devoted to "geographical distribution." The means of transport are partly active, partly passive; that is to say, the organism effects its migration partly by free locomotion due to its own activity, and partly by the movements of other natural bodies in which it has no active share.

It is self-evident that *active migrations* play the chief part in animals able to move freely. The more freely an animal's organization permits it to allmove in directions, the more easily the animal species can migrate, and the more rapidly it will spread over the earth. *Flying* animals are of course most favoured in this respect, among vertebrate animals especially birds, and among articulated animals, insects. These two classes, as soon as they came into existence, can

have more easily spread over the whole earth than any other animal, and this fact partly explains the extraordinary uniformity of structure which characterizes these two great classes of animals. For, although they contain an exceedingly large number of different species, and although the insect class alone is said to possess more different species than all other classes of animals together, yet all the innumerable species of insects, and in like manner, also, the different species of birds, agree most strikingly in all essential peculiarities of their organization. Hence, in the class of insects, as well as in that of birds, we can distinguish only a very small number of large natural groups or orders, and these few orders differ but very little from one another in their internal structure. The orders of birds with their numerous species are not nearly as distinct from one another as the orders of the mammalian class, containing much fewer species; and the orders of insects, which are extremely rich in genera and species, resemble one another much more closely in their internal structure than do the much smaller orders of the crab class. The general parallelism between birds and insects is also very interesting in relation to systematic zoology; and the great importance of their richness in forms, for scientific morphology, lies in the fact that they show us how, within the narrowest anatomical sphere, and without profound changes of the essential internal organization, the greatest variety in external bodily forms can be attained. The reason of this is evidently their flying mode of life and their free locomotion. In consequence of this birds, as well as insects, have spread very rapidly over the whole surface of the earth, have settled in all possible localities inaccessible to other animals, and variously modified

their specific form by superficial adaptation to particular local relations.

Next to the flying animals, those animals, of course, have spread most quickly and furthest which were next best able to migrate, that is, the best runners among the inhabitants of the land, and the best swimmers among the inhabitants of the water. However, the power of such active migrations is not confined to those animals which throughout life enjoy free locomotion. For the fixed animals also, such as corals, tubicolous worms, sea-squirts, lily encrinites, sea-acorns, barnacles, and many other lower animals which adhere to seaweeds, stones, etc., enjoy, at least at an early period of life, free locomotion. They all migrate before they adhere to anything. Their first free locomotive condition of early life is generally that of a "ciliated" larva, a roundish, cellular corpuscle, which, by means of a garb of movable "flimmer-hairs," (Latin, "cilia") swarms about in the water and bears the name of Planula.

But the power of free locomotion, and hence, also, of active migration, is not confined to animals alone, but many plants likewise enjoy it. Many lower aquatic plants, especially the class of the Tangles (*Algæ*), swim about freely in the water in early life, like the lower animals just mentioned, by means of a vibratile hairy coat, a vibrating whip, or a covering of tremulous fringes, and only at a later period adhere to objects. Even in the case of many higher plants, which we designate as creepers and climbing plants, we may speak of active migration. Their elongated stalks and perennial roots creep or climb during their long process of growth to new positions, and by means of their widespread branches they acquire new habitations, to which

they attach themselves by buds, and bring forth new colonies of individuals of their species.

Influential as these active migrations of most animals and many plants are, yet alone they would by no means be sufficient to explain the chorology of organisms. *Passive migrations* have ever been by far the more important, and of far greater influence, in the case of most plants and in that of many animals. Such passive changes of locality are produced by extremely numerous causes. Air and water in their eternal motion, wind and waves with their manifold currents, play the chief part. The wind in all places and at all times raises light organisms, small animals and plants, but especially their young germs, animal eggs and plant seeds, and carries them far over land and seas. Where they fall into the water they are seized by currents or waves and carried to other places. It is well known, from numerous examples, how far in many cases trunks of trees, hard shelled fruits, and other not readily perishable portions of plants are carried away from their original home by the course of rivers and by the currents of the sea. Trunks of palm trees from the West Indies are brought by the Gulf Stream to the British and Norwegian coasts. All large rivers bring down driftwood from the mountains, and frequently alpine plants are carried from their home at the source of the river into the plains, and even further, down to the sea. Frequently numerous inhabitants live between the roots of the plants thus carried down, and between the branches of the trees thus washed away there are various inhabitants which have to take part in the passive migration. The bark of the tree is covered with mosses, lichens, and parasitic insects. Other insects, spiders,

etc., even small reptiles and mammals, are hidden within the hollow trunk or cling to the branches. In the earth adhering to the fibres of the roots, in the dust lying in the cracks of the bark, there are innumerable germs of smaller animals and plants. Now, if the trunk thus washed away lands safely on a foreign shore or on a distant island, the guests who had to take part in the involuntary voyage can leave their boat and settle in the new country. A very remarkable kind of water-transport is formed by the floating icebergs which annually become loosened from the eternal ice of the Polar Sea. Although these cold regions are thinly peopled, yet many of their inhabitants, who were accidentally upon an iceberg while it was becoming loosened, are carried away with it by the currents, and landed on warmer shores. In this manner, by means of loosened blocks of ice from the northern Polar Sea, often whole populations of small animals and plants have been carried to the northern shores of Europe and America. Nay, even polar foxes and polar bears have been carried in this way to Iceland and to the British Isles.

Transport by air is no less important than transport by water in this matter of passive migration. The dust covering our streets and roofs, the earth lying on dry fields and dried-up pools, the light moist soil of forests, in short, the whole surface of the globe contains millions of small organisms and their germs. Many of these small animals and plants can without injury become completely dried up, and awake again to life as soon as they are moistened. Every gust of wind raises up with the dust innumerable little creatures of this kind, and often carries them away to other places miles off. But even larger organisms, and especially

their germs, may often make distant passive journeys through the air. The seeds of many plants are provided with light feathery processes, which act as parachutes and facilitate their flight in the air, and prevent their falling. Spiders make journeys of many miles through the air on their fine filaments, their so-called gossamer threads. Young frogs are frequently raised by whirlwinds into the air by thousands, and fall down in a distant part as a "shower of frogs." Storms may carry birds and insects across half the earth's circumference. They drop in the United States, having risen in England. Starting from California, they only come to rest in China. But, again, many other organisms may make the journey from one continent to another together with the birds and insects. Of course all parasites, the number of which is legion, fleas, lice, mites, moulds, etc., migrate with the organisms upon which they live. In the earth which often remains sticking to the claws of birds there are also small animals and plants or their germs. Thus the voluntary or involuntary migration of a single larger organism may carry a whole small flora and fauna from one part of the earth to another.

Besides the means of transport here mentioned, there are many others which explain the distribution of animal and vegetable species over the large tracts of the earth's surface, and especially the general distribution of the so-called cosmopolitan species. But these alone would not nearly be sufficient to explain all chorological facts. How is it, for example, that many inhabitants of fresh water live in various rivers or lakes far away and quite apart from one another? How is it that many inhabitants of mountains, which cannot exist in plains, are found upon entirely

separated and far distant chains of mountains? It is difficult to believe, and in many cases quite inconceivable, that these inhabitants of fresh water should have in any way, actively or passively, migrated over the land lying between the lakes, or that the inhabitants of mountains in any way, actively or passively, crossed the plains lying between their mountain homes. But here geology comes to our help, as a mighty ally, and completely solves these difficult problems for us.

The history of the earth's development shows us that the distribution of land and water on its surface is ever and continually changing. In consequence of geological changes of the earth's crust, *elevations* and *depressions* of the ground take place everywhere, sometimes more strongly marked in one place, sometimes in another. Even if they happen so slowly that in the course of centuries the seashore rises or sinks only a few inches, or even only a few lines, still they nevertheless effect great results in the course of long periods of time. And long—immeasurably long—periods of time have not been wanting in the earth's history. During the course of many millions of years, ever since organic life existed on the earth, land and water have perpetually struggled for supremacy. Continents and islands have sunk into the sea, and new ones have arisen out of its bosom. Lakes and seas have slowly been raised and dried up, and new water basins have arisen by the sinking of the ground. Peninsulas have become islands by the narrow neck of land which connected them with the mainland sinking into the water. The islands of an archipelago have become the peaks of a continuous chain of mountains by the whole floor of their sea being considerably raised.

Thus the Mediterranean at one time was an inland sea, when, in the place of the Straits of Gibraltar, an isthmus connected Africa with Spain. England, even during the more recent history of the earth, when man already existed, has repeatedly been connected with the European continent and been repeatedly separated from it. Nay, even Europe and North America have been directly connected. The South Sea at one time formed a large Pacific Continent, and the numerous little islands which now lie scattered in it were simply the highest peaks of the mountains covering that continent. The Indian Ocean formed a continent which extended from the Sunda Islands along the southern coast of Asia to the east coast of Africa. This large continent of former times Sclater, an Englishman, has called *Lemuria*, from the monkey-like animals which inhabited it, and it is at the same time of great importance from being the probable cradle of the human race, which in all likelihood here first developed out of anthropoid apes. The important proof which Alfred Wallace has furnished,³⁶ by the help of chorological facts, that the present Malayan Archipelago consists in reality of two completely different divisions, is particularly interesting. The western division, the Indo-Malayan Archipelago, comprising the large islands of Borneo, Java, and Sumatra, was formerly connected by Malacca with the Asiatic continent, and probably also with the Lemurian continent just mentioned. The eastern division, on the other hand, the Austro-Malayan Archipelago, comprising Celebes, the Moluccas, New Guinea, Solomon's Islands, etc., was formerly directly connected with Australia. Both divisions were formerly two continents separated

by a strait, but they have now for the most part sunk below the level of the sea. Wallace, solely on the ground of his accurate chorological observations, has been able in the most acute manner to determine the position of this former strait, the south end of which passes between Bali and Lombok.

Thus, ever since liquid water existed on the earth, the boundaries of water and land have eternally changed, and we may assert that the outlines of continents and islands have never remained for an hour, nay, even for a minute, exactly the same. For the waves eternally and perpetually break on the edge of the coast, and whatever the land in these places loses in extent, it gains in other places by the accumulation of mud, which condenses into solid stone and again rises above the level of the sea as new land. Nothing can be more erroneous than the idea of a firm and unchangeable outline of our continents, such as is impressed upon us in early youth by defective lessons on geography, which are devoid of a geological basis.

I need hardly draw attention to the fact that these geological changes of the earth's surface have ever been exceedingly important to the migrations of organisms, and consequently to their Chorology. From them we learn to understand how it is that the same or nearly related species of animals and plants can occur on different islands, although they could not have passed through the water separating them, and how other species living in fresh water can inhabit different enclosed water-basins, although they could not have crossed the land lying between them. These islands were formerly mountain peaks of a connected continent, and these lakes were once directly connected with one another.

The former were separated by geological depressions the latter by elevations. Now, if we further consider how often and how unequally these alternating elevations and depressions occur on the different parts of the earth, and how, in consequence of this, the boundaries of the geographical tracts of distribution of species become changed, and if we further consider in what exceedingly various ways the active and passive migrations of organisms must have been influenced by them, then we shall be in a position to completely understand the great variety of the picture which is at present offered to us by the distribution of animal and vegetable species.

There is yet another important circumstance to be mentioned here, which is likewise of great importance for a complete explanation of this varied geographical picture, and which throws light upon many very obscure facts, which, without its help, we should not be able to comprehend. I mean the gradual *change of climate* which has taken place during the long course of the organic history of the earth. As we saw in our last chapter, at the beginning of organic life on the earth a much higher and more equal temperature must have generally prevailed than at present. The differences of zones, which in our time are so very striking, did not exist at all in those times. It is probable that for many millions of years but one climate prevailed over the whole earth, which very closely resembled, or even surpassed, the hottest tropical climate of the present day. The highest north which man has yet reached was then covered with palms and other tropical plants, the fossil remains of which are still found there. The temperature of this climate at a later period gradually decreased; but still

the poles remained so warm that the whole surface of the earth could be inhabited by organisms. It was only at a comparatively very recent period of the earth's history, namely, at the beginning of the tertiary period, that there occurred, as it seems, the first perceptible cooling of the earth's crust at the poles, and through this the first differentiation or separation of the different zones of temperature or climatic zones. But the slow and gradual decrease of temperature continued to extend more and more within the tertiary period, until at last, at both poles of the earth, the first permanent ice caps were formed.

I need scarcely point out in detail how very much this change of climate must have affected the geographical distribution of organisms, and the origin of numerous new species. The animal and vegetable species, which, down to the tertiary period, had found an agreeable tropical climate all over the earth, even as far as the poles, were now forced either to adapt themselves to the intruding cold, or to flee from it. Those species which adapted and accustomed themselves to the decreasing temperature became new species simply by this very acclimatization, under the influence of natural selection. The other species, which fled from the cold, had to emigrate and seek a milder climate in lower latitudes. The tracts of distribution which had hitherto existed must by this have been vastly changed.

However, during the last great period of the earth's history, during the quaternary period (or diluvial period) succeeding the tertiary one, the decrease of the heat of the earth from the poles did not by any means remain stationary. The temperature fell lower and lower, nay, even

far below the present degree. Northern and Central Asia, Europe, and North America from the north pole, were covered to a great extent by a connected sheet of ice, which in our part of the earth seems to have reached the Alps. In a similar manner the cold also advancing from the south pole covered a large portion of the southern hemisphere, which is now free from it, with a rigid sheet of ice. Thus, between these vast lifeless ice continents there remained only a narrow zone to which the life of the organic world had to withdraw. This period, during which man, or at least the human ape, already existed, and which forms the first period of the so-called *diluvial epoch*, is now universally known as the *ice* or *glacial period*.

The ingenious Carl Schimper is the first naturalist who clearly conceived the idea of the ice period, and proved the great extent of the former glaciation of Central Europe by the help of the so-called boulders, or erratic blocks of stone, as also by the "glacier tables." Louis Agassiz, stimulated by him, and considerably supported by the independent investigations of the eminent geologist Charpentier, afterwards undertook the task of carrying out the theory of the ice period. In England, the geologist Forbes distinguished himself in this matter, and also was the first to apply it to the theory of migrations and the geographical distribution of species dependent upon migration. Agassiz, however, afterwards injured the theory by his one-sided exaggeration, inasmuch as, from his partiality to Cuvier's theory of cataclysms, he endeavoured to attribute the destruction of the whole animate creation then existing, to the sudden coming on of the cold of the ice period and the "revolution" connected with it.

It is unnecessary here to enter into detail as to the ice period itself, and into investigations about its limits, and I may omit this all the more reasonably since the whole of our recent geological literature is full of it. It will be found discussed in detail in the works of Cotta,³¹ Lyell,³⁰ Vogt,²⁷ Zittel,³² etc. Its great importance to us here is that it helps us to explain the most difficult chorological problems, as Darwin has correctly perceived.

For there can be no doubt that this glaciation of the present temperate zones must have exercised an exceedingly important influence on the geographical and topographical distribution of organisms, and that it must have entirely changed it. While the cold slowly advanced from the poles towards the equator, and covered land and sea with a connected sheet of ice, it must of course have driven the whole living world before it. Animals and plants had to migrate if they wished to escape being frozen. But as at that time the temperate and tropical zones were probably no less densely peopled with animals and plants than at present, there must have arisen a fearful struggle for life between the latter and the intruders coming from the poles. During this struggle, which certainly lasted many thousands of years, many species must have perished and many become modified and been transformed into new species. The hitherto existing tracts of distribution of species must have become completely changed, and the struggle have been continued, nay, indeed, must have broken out anew and been carried on in new forms, when the ice period had reached and gone beyond its furthest point, and when in the post-glacial period the temperature again increased, and organisms began to migrate back again towards the poles.

In any case this great change of climate, whether a greater or less importance be ascribed to it, is one of those occurrences in the history of the earth which have most powerfully influenced the distribution of organic forms. But more especially one important and difficult chorological circumstance is explained by it in the simplest manner, namely, the specific agreement of many of our Alpine inhabitants with some of those living in polar regions. There is a great number of remarkable animal and vegetable forms which are common to these two far distant parts of the earth, and which are found nowhere in the wide plains lying between them. Their migration from the polar lands to the Alpine heights, or *vice versa*, would be inconceivable under the present climatic circumstances, or could be assumed at least only in a few rare instances. But such a migration could take place, nay, was obliged to take place, during the gradual advance and retreat of the ice-sheet. As the glaciation encroached from Northern Europe towards our Alpine chains, the polar inhabitants retreating before it—gentian, saxifrage, polar foxes, and polar hares—must have peopled Germany, in fact all Central Europe. When the temperature again increased, only a portion of these Arctic inhabitants returned with the retreating ice to the Arctic zones. Another portion of them climbed up the mountains of the Alpine chain instead, and there found the cold climate suited to them. The problem is thus solved in a most simple manner.

We have hitherto principally considered the *theory of the migrations* of organisms in so far as it explains the radiation of every animal and vegetable species from a single primæval home, from a "central point of creation," and the

dispersion of these species over a greater or less portion of the earth's surface. But these migrations are also of great importance to the theory of development, because we can perceive in them a very important means for the *origin of new species*. When animals and plants migrate they meet in their new home, in the same way as do human emigrants, with conditions which are more or less different from those which they have inherited throughout generations, and to which they have been accustomed. The emigrants must either submit and adapt themselves to these new conditions of life or they perish. By adaptation their peculiar specific character becomes the more changed the greater the difference between the new and the old home. The new climate, the new food, but above all, new neighbours in the forms of other animals and plants, influence and tend to modify the inherited character of the immigrant species, and if it is not hardy enough to resist the influences, then sooner or later a new species must arise out of it. In most cases this transformation of an immigrant species takes place so quickly under the influence of the altered struggle for life, that even after a few generations a new species arises from it.

Migration has an especial influence in this way on all organisms with separate sexes. For in them the origin of new species by natural selection is always rendered difficult, or delayed, by the fact that the modified descendants occasionally again mix sexually with the unchanged original form, and thus by crossing return to the first form. But if such varieties have migrated, if great distances or barriers to migration—seas, mountains, etc.—have separated them from the old home, then the danger of a mingling

with the primary form is prevented, and the isolation of the emigrant form, which becomes a new species by adaptation, prevents its breeding with the old stock, and hence prevents its return in this way to the original form.

The importance of migration for the isolation of newly-originating species and the prevention of a speedy return to the primary form has been especially pointed out by the philosophic traveller, Moritz Wagner, of Munich. In a special treatise on "Darwin's Theory and the Law of the Migration of Organisms,"⁴⁰ Wagner gives from his own rich experience a great number of striking examples which confirm the theory of migration set forth by Darwin in the eleventh and twelfth chapters of his book, where he especially discusses the effect of the complete isolation of emigrant organisms in the origin of new species. Wagner sets forth the simple causes which have "locally bounded the form and founded its typical difference," in the following three propositions:—1. The greater the total amount of change in the hitherto existing conditions of life which the emigrating individuals find on entering a new territory, the more intensely must the innate variability of every organism manifest itself. 2. The less this increased individual variability of organisms is disturbed in the peaceful process of reproduction by the mingling of numerous subsequent immigrants of the same species, the more frequently will nature succeed, by intensification and transmission of the new characteristics, in forming a new variety or race, that is, a commencing species. 3. The more advantageous the changes experienced by the individual organs are to the variety, the more readily will it be able to adapt itself to the surrounding conditions; and the longer the undis-

turbed breeding of a commencing variety of colonists in a new territory continues without its mingling with subsequent immigrants of the same species, the oftener a new species will arise out of the variety."

Every one will agree with these three propositions of Moritz Wagner's. But we must consider his view, that the migration and the subsequent isolation of the emigrant individuals is a *necessary* condition for the origin of new species, to be completely erroneous. Wagner says, "without a long-enduring separation of colonists from their former species, the formation of a new race cannot succeed—selection, in fact, cannot take place. Unlimited crossing, unhindered sexual mingling of all individuals of a species will always produce uniformity, and drive varieties, whose characteristics have not been fixed throughout a series of generations, back to the primary form."

This sentence, in which Wagner himself comprises the main result of his investigations, he would be able to defend only if all organisms were of separate sexes, if every origin of new individuals were possible only by the mingling of male and female individuals. But this is by no means the case. Curiously enough, Wagner says nothing of the numerous hermaphrodites which, possessing both the sexual organs, are capable of self-fructification, and likewise nothing of the countless organisms which are not sexually differentiated.

Now, from the earliest times of the organic history of the earth, there have existed thousands of organic species (thousands of which still exist) in which no difference of sex whatever exists, and, in fact, in which no sexual propagation takes place, and which exclusively reproduce them-

selves in a non-sexual manner by division, budding, formation of spores, etc. All the great mass of Protista, the Monera, Amœbæ, Myxomycetes, Rhizopoda, etc., in short, all the lower organisms which we shall have to enumerate in the domain of Protista, standing midway between the animal and vegetable kingdoms, propagate themselves *exclusively in a non-sexual manner*. And this domain comprises a class of organisms which is one of the richest in forms, nay, even in a certain respect the richest of all in forms, as all possible geometrical fundamental forms are represented in it. I allude to the wonderful class of the Rhizopoda, or Ray-streamers, to which the lime-shelled Acyttaria and the flint-shelled Radiolaria belong. (Compare chapter xvi.)

It is self-evident, therefore, that Wagnër's theory is quite inapplicable to all these non-sexual organisms. Moreover, the same applies to all those hermaphrodites in which every individual possesses both male and female organs and is capable of self-fructification. This is the case, for instance, in the Flat-worms, flukes, and tapeworms, further in the important Sack-worms (Tunicates), the invertebrate relatives of the vertebrate animals, and in very many other organisms of different groups. Many of these species have arisen by natural selection, without a "crossing" of the originating species with its primary form having been possible.

As I have already shown in the eighth chapter, the origin of the two sexes, and consequently sexual propagation in general, must be considered as a process which began only in later periods of the organic history of the earth, being the result of differentiation or *division of labour*. The most ancient terrestrial organisms can have propagated themselves

only in the simplest non-sexual manner. Even now all Protista, as well as all the countless forms of cells, which constitute the body of higher organisms, multiply themselves only by non-sexual generation. And yet there arise here "new species" by differentiation in consequence of natural selection.

But even if we were to take into consideration the animal and vegetable species with separate sexes, in this case too we should have to oppose Wagner's chief proposition, that "*the migration of organisms and their formation of colonies is the necessary condition of natural selection.*" August Weismann, in his treatise on the "Influence of Isolation upon the Formation of Species," ²⁴ has already sufficiently refuted that proposition, and has shown that even in one and the same district one bi-sexual species may divide itself into several species by natural selection. In relation to this question, I must again call to mind the great influence which *division of labour, or differentiation*, possesses, being one of the necessary results of natural selection. All the different kinds of cells constituting the body of the higher organisms, the nerve cells, muscle cells, gland cells, etc., all these "good species," these "*bonæ species*" of elementary organisms, have arisen solely by division of labour, in consequence of natural selection, although they not only never were locally isolated, but ever since their origin have always existed in the closest local relations one with another. Now, the same reasoning that applies to these elementary organisms, or "*individuals of the first order*," applies also to the many-celled organisms of a higher order which only at a later date have arisen as "*good species*" from among their fellows.

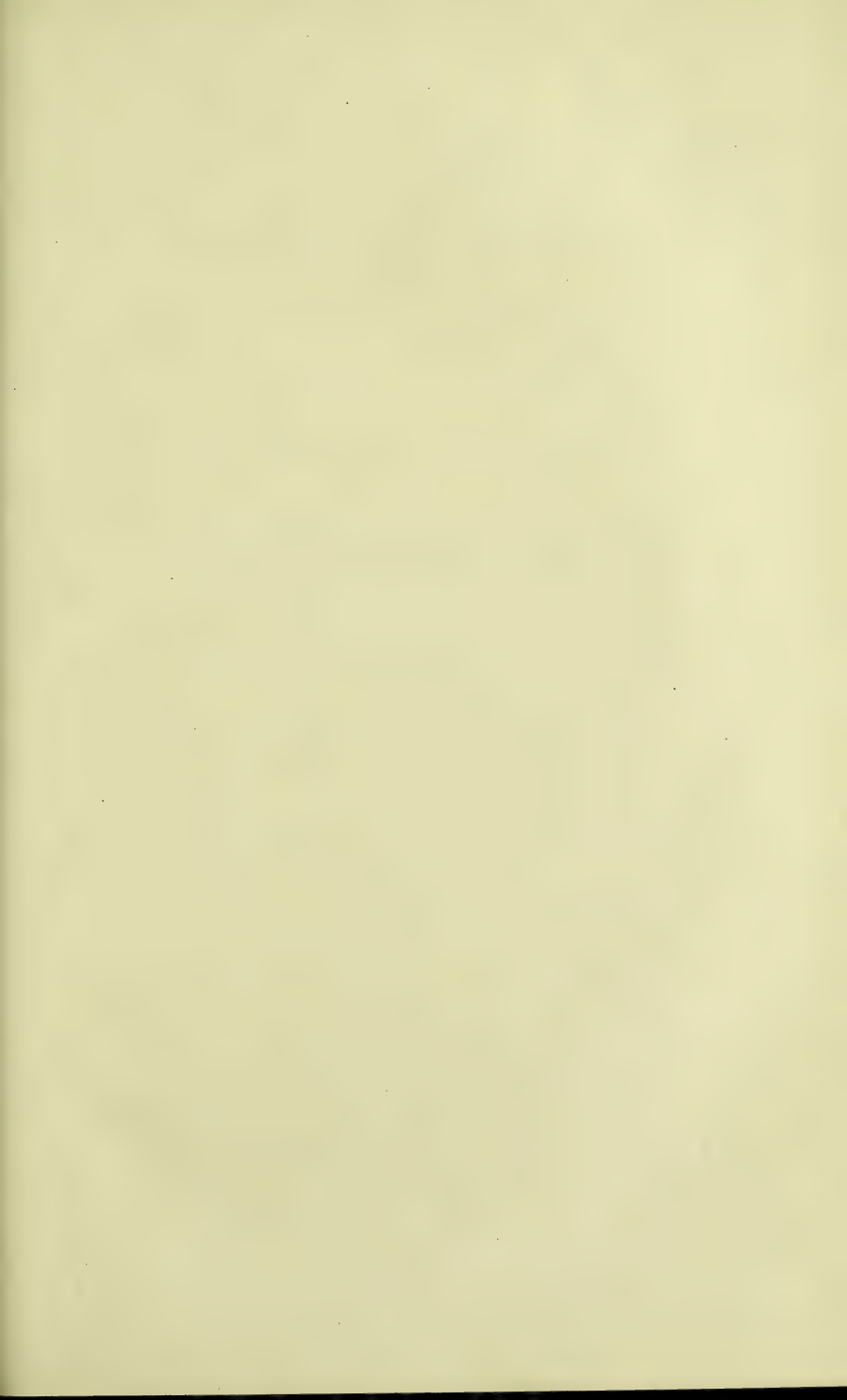
We are therefore of the same opinion as Darwin and Wallace, that the migration of organisms and their isolation in their new home is a very advantageous condition for the origin of new species; but we cannot admit, as Wagner asserts, that it is a *necessary* condition, and that without it no species can arise. Wagner sets up this opinion, "that migration is a necessary condition for natural selection," as a special "*law of migration*"; but we consider it sufficiently refuted by the above-mentioned facts. We have, moreover, already pointed out that in reality the origin of new species by natural selection is a *mathematical and logical necessity* which, without anything else, follows from the simple combination of three great facts. These three fundamental facts are—the Struggle for Life, the Adaptability, and the Hereditivity of organisms.

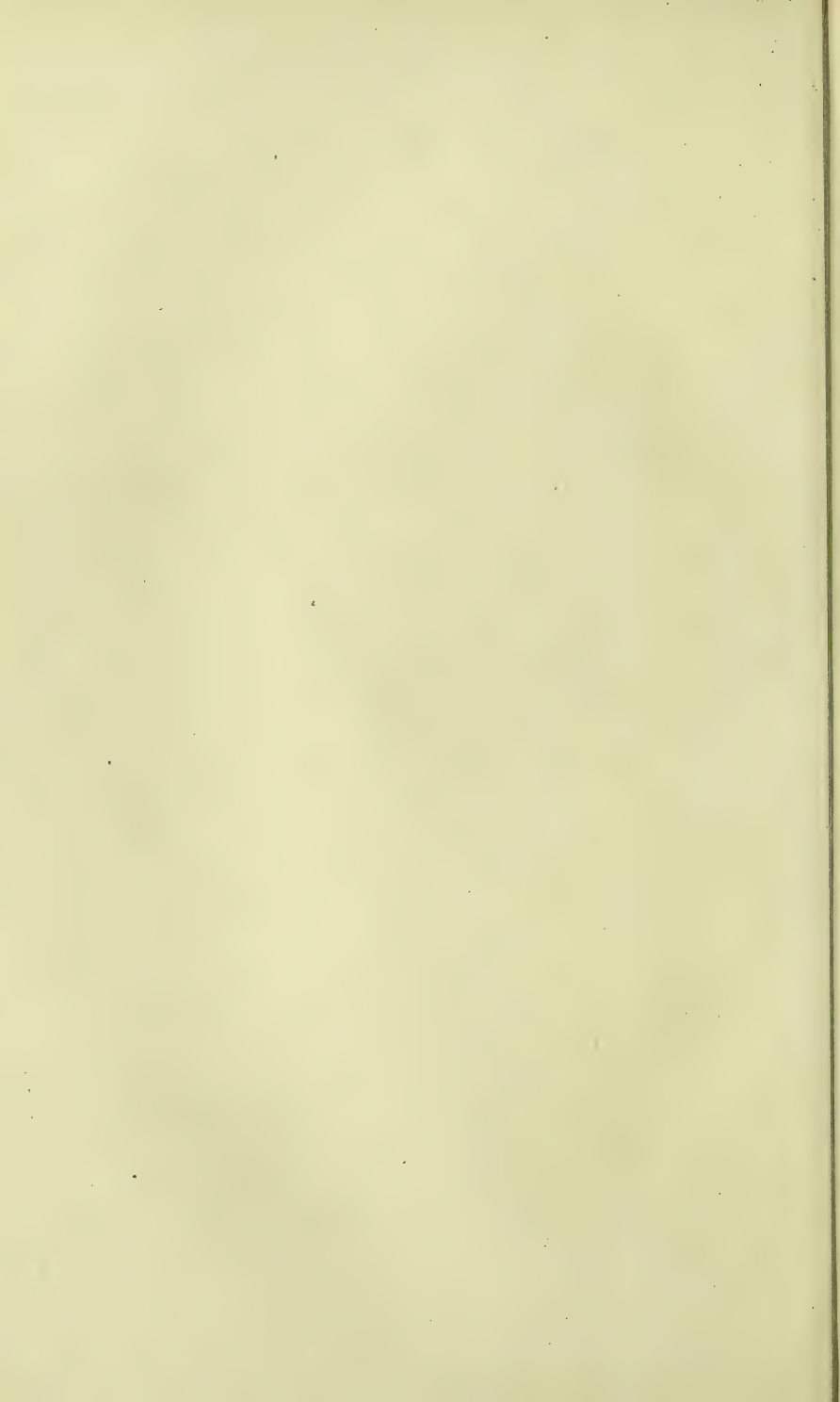
We cannot here enter into detail concerning the numerous interesting phenomena furnished by the geographical and topographical distribution of organic species, which are all wonderfully explained by the theory of selection and migration. For these I refer to the writings of Darwin,¹ Wallace,³⁶ and Moritz Wagner,⁴⁰ in which the important doctrine of the *limits of distribution*—seas, rivers, and mountains—is excellently discussed and illustrated by numerous examples. Only three other phenomena must be mentioned here on account of their special importance. First, the close relation of forms, that is, the striking "family likeness" existing between the characteristic local forms of every part of the globe, and their extinct fossil ancestors in the same part of the globe; secondly, the no less striking "family likeness" between the inhabitants of island groups and those of the neighbouring continent from which the

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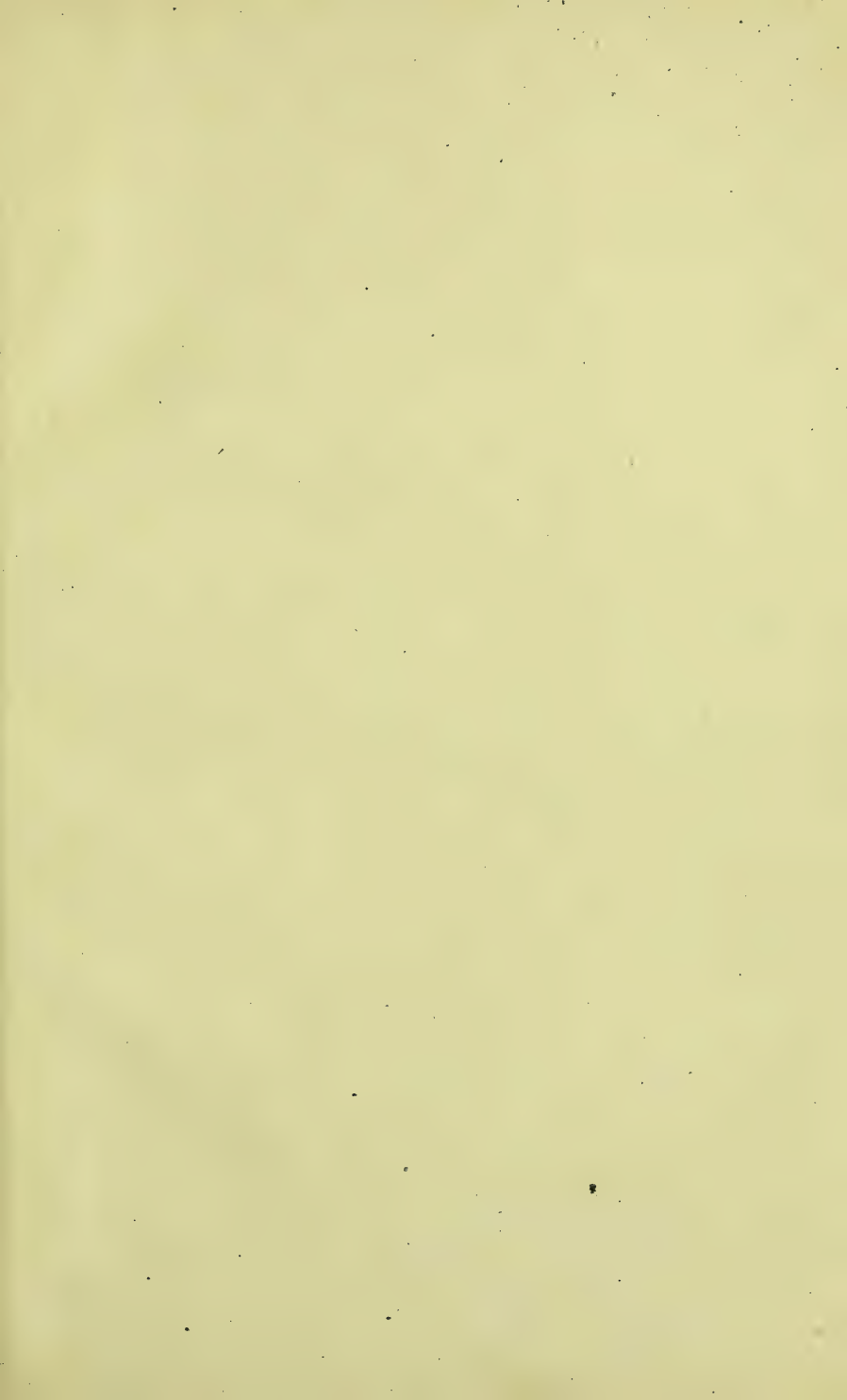
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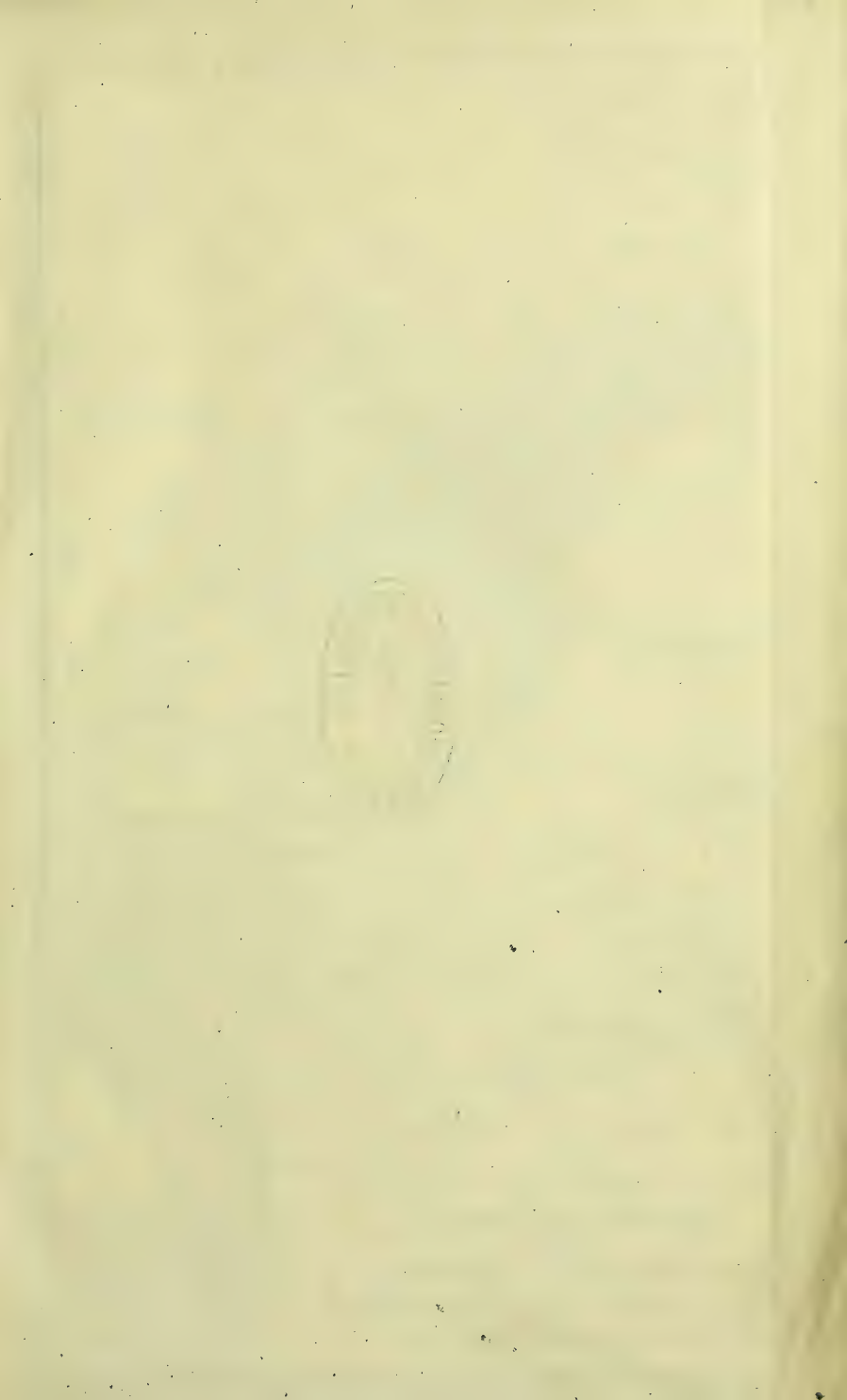
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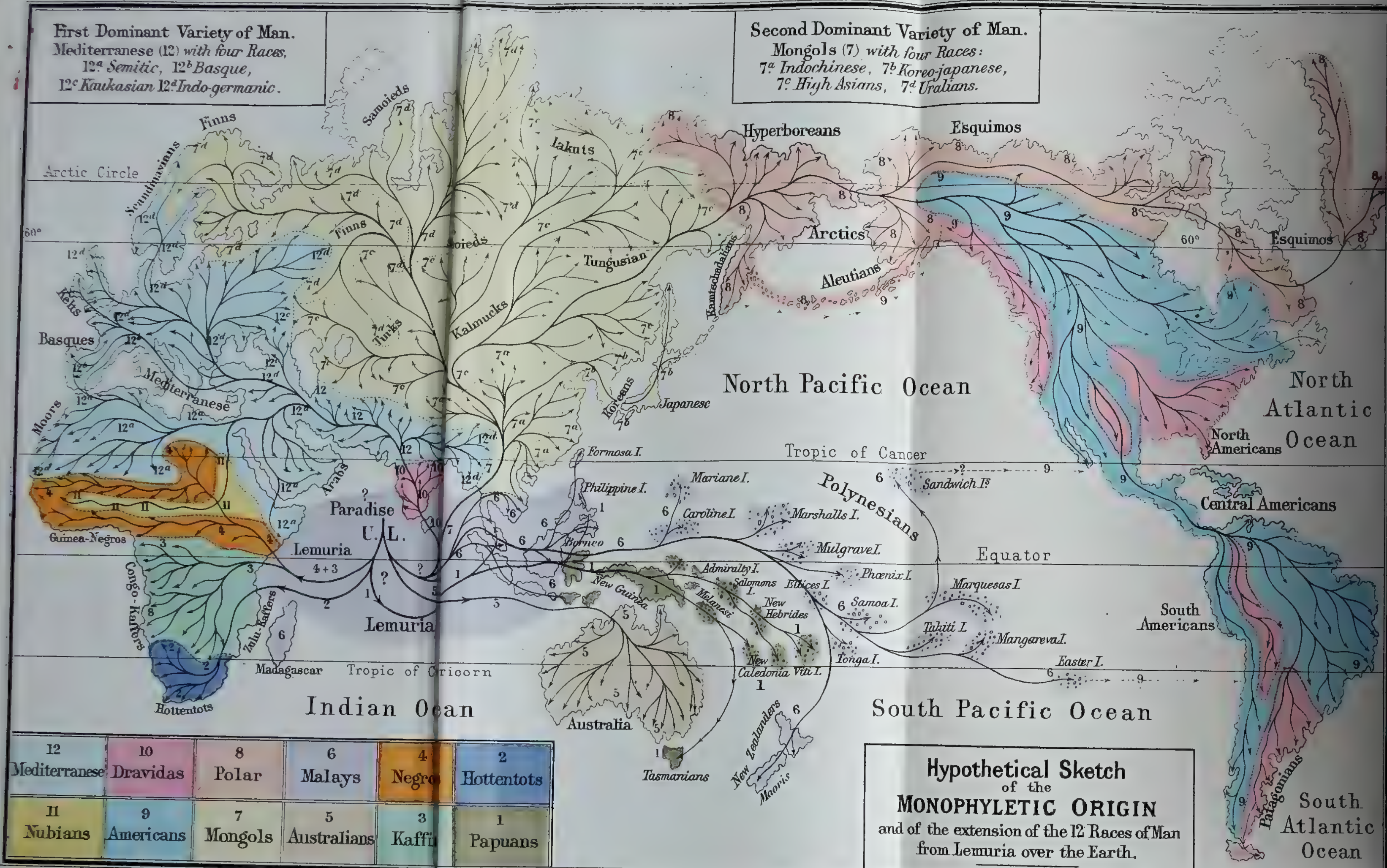
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CHAPTER XV.

PERIODS OF CREATION AND RECORDS OF CREATION.

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THE revolutionary influence which the Theory of Descent must exercise upon all sciences, will in all probability affect no branch of science, excepting Anthropology, so much as the descriptive portion of natural history, that which is known as systematic Zoology and Botany. Most naturalists who have hitherto occupied themselves with arranging the different systems of animals and plants, have collected, named, and arranged the different species of these natural bodies

with much the same interest as antiquarians and ethnographers collect the weapons and utensils of different nations. Many have not even risen above the degree of intelligence with which people usually collect, label, and arrange crests, stamps, and similar curiosities. In the same manner as some collectors find their pleasure in the similarity of forms, the beauty or rarity of the crests or stamps, and admire in them the inventive art of man, so many naturalists take a delight in the manifold forms of animals and plants, and marvel at the rich imagination of the Creator, at His unwearied creative activity, and at His curious fancy for forming, by the side of so many beautiful and useful organisms, also a number of ugly and useless ones.

This childlike treatment of systematic Zoology and Botany is completely annihilated by the Theory of Descent. In the place of the superficial and playful interest with which most naturalists have hitherto regarded organic structures, we now have the much higher interest of the intelligent understanding which detects in the *related forms* of organisms their true *blood relationships*. The *Natural System of animals and plants*, which was formerly valued either only as a registry of names, to facilitate the survey of the different forms, or as a table of contents for the short expression of their degrees of similarity, receives from the Theory of Descent the incomparably higher value of a true *pedigree of organisms*. This pedigree is to disclose to us the genealogical connection of the smaller and larger groups. It has to show us in what way the different classes, orders, families, genera, and species of the animal and vegetable kingdoms correspond with the different branches, twigs, and groups of twigs of the pedigree. Every wider and higher category

or stage of the system (for example a class, or an order) comprises a number of larger and stronger branches of the pedigree; every narrower and lower category (for example a genus, or a species) only a smaller and thinner group of twigs. It is only when we thus view the natural system as a pedigree that we perceive its true value. (Gen. Morph. ii. Plate XVII. 397.)

Since we hold fast this genealogical conception of the Organic System, to which alone undoubtedly the future of classificatory Zoology and Botany belongs, we should now turn our attention to one of the most essential, but also one of the most difficult, tasks of the "non-miraculous history of creation," namely, to the actual construction of the Organic Pedigree. Let us see how far we are already able to point out all the different organic forms as the divergent descendants of a single or of some few common original forms. But how can we construct the actual pedigree of the animal and vegetable group of forms from our knowledge of them, at present so scanty and fragmentary? The answer to this question lies in what we have already remarked of the parallelism of the three series of development—in the important causal relation which connects the palæontological development of all organic tribes with the embryological development of individuals, and with the systematic development of groups.

In order to accomplish our task we shall first have to direct our attention to *palæontology*, or *the science of petrifications*. For if the Theory of Descent is really true, if the petrified remains of formerly living animals and plants really proceed from the extinct primæval ancestors and progenitors of the present organisms, then, without any-

thing else, the knowledge and comparison of petrifications ought to disclose to us the pedigree of organisms. However simple and clear this may seem in theory, the task becomes extremely hard and complicated when it is actually taken in hand. Its practical solution would be very difficult even if the petrifications were to any extent completely preserved. But this is by no means the case. The obvious records of creation which lie buried in petrifications are imperfect beyond all measure. Hence it is necessary critically to examine these records, and to determine the value which petrifications possess for the history of the development of organic tribes. As I have previously discussed the general importance of petrifications as the records of creation, when we were considering Cuvier's merits in the science of fossils, we may now at once examine the conditions and circumstances under which the remains of organic bodies became petrified and preserved in a more or less recognizable form.

As a rule we find petrifications or fossils enclosed only in those stones which have been deposited in layers as mud by water, and which are on that account called neptunic, stratified, or sedimentary rocks. The deposition of such strata could of course only commence after the condensation of watery vapour into liquid water had taken place in the course of the earth's history. After that period, which we considered in our last chapter, not only did life begin on the earth, but also an uninterrupted and exceedingly important transformation of the rigid inorganic crust of the earth. The water began that extremely important mechanical action by which the surface of the earth is perpetually, though slowly, transformed. I may surely presume that it is generally known what an extremely

important influence, in this respect, is even yet exercised by water at every moment. As it falls down as rain, trickling through the upper strata of the earth's crust, and flowing down from heights into hollows, it chemically dissolves different mineral parts of the ground, and mechanically washes away the loose particles. In flowing down from mountains water carries their débris into the plains, or deposits it as mud in stagnant lakes. Thus it continually works at lowering mountains and filling up valleys. In like manner the breakers of the sea work uninterruptedly at the destruction of the coasts and at filling up the bottom of the sea with the débris they wash down. The action of water alone, if it were not counteracted by other circumstances, would in time level the whole earth. There can be no doubt that the mountain masses—which are annually carried down as mud into the sea, and deposited on its floor—are so great that in the course of a longer or shorter period, say a few millions of years, the surface of the earth would be completely levelled and become enclosed by a continuous sheet of water. That this does not happen is owing to the perpetual volcanic action of the fiery-fluid centre of the earth. The surging of the melted nucleus against the firm crust necessitates continual alternations of elevation and depression on the different parts of the earth's surface. These elevations and depressions for the most part take place very slowly; but, as they continue for thousands of years, by the combined effect of small, interrupted movements, they produce results no less grand than does the counteracting and levelling action of water.

Since the elevations and depressions of the different parts

of the earth alternate with one another in the course of millions of years, first this and then that part of the earth's surface is above or below the level of the sea. I have already given examples of this in the preceding chapter (vol. i. p. 361). Hence, in all probability, there is no part of the outer crust of the earth which has not been repeatedly above and also below the level of the sea. This repeated change explains the variety and the different composition of the numerous neptunic strata of rocks, which in most places have been deposited one above another in considerable thickness. In the different periods of the earth's history during which these deposits took place there lived various and different populations of animals and plants. When their dead bodies sank to the bottom of the waters, the forms of the bodies impressed themselves upon the soft mud, and imperishable parts, such as hard bones, teeth, shells, etc., became enclosed in it uninjured. These were preserved in the mud, which condensed them into neptunic rock, and as petrifications they now serve to characterize the respective strata. By a careful comparison of the different strata lying one above another, and the petrifications preserved in them, it has become possible to decide the relative age of the strata and groups of strata, and to establish, by direct observation, the principal eras of phylogeny, that is to say, the stages in history of the development of animal and vegetable tribes.

The different strata of neptunic rocks deposited one above another, which are composed in very various ways of limestone, clay, and sand, geologists have grouped together into an ideal System or Series, which corresponds with the whole course of the organic history of the earth, or with that portion

of the earth's history during which organic life existed. Just as so-called "universal history" falls into larger and smaller periods, which are characterized by the conditions of development of the most important nations at the respective epochs, and are separated from one another by great events, so we also divide the infinitely longer organic history of the earth into a series of greater and less periods. Each of these periods is distinguished by a characteristic flora and fauna, and by the specially strong development of certain vegetable or animal groups, and each is separated from the preceding and succeeding period by a striking change in the character of its animal and vegetable inhabitants.

In relation to the following survey of the historical course of development which the large animal and vegetable tribes have passed through, it will be desirable to say a few words first as to the systematic classification of the neptunic groups of strata, and the larger and smaller periods corresponding to them. As will be seen directly, we are able to divide the whole of the sedimentary rocks lying one above another into five main groups or periods, each period into several subordinate groups of strata or *systems*, and each system of strata again into still smaller groups or *formations*; finally, each formation can again be divided into stages or sub-formations, and each of these again into still smaller layers or beds. Each of the five great rock-groups was deposited during a great division of the earth's history, during a long *era* or *epoch*; each system during a shorter *period*; each formation during a still shorter *period*. In thus reducing the periods of the organic history of the earth, and the neptunic strata containing petrifications deposited during those periods, into a connected system, we proceed exactly

like the historian who divides the history of nations into the three main divisions of Antiquity, the Middle Ages, and Modern Times, and each of these sections again into subordinate periods and epochs. But the historian by this sharp systematic division, and by fixing the boundary of the periods by particular dates, only seeks to facilitate his survey, and in no way means to deny the uninterrupted connection of events and the development of nations. Exactly the same qualification applies to our systematic division, specification, or classification of the organic history of the earth. Here, too, a continuous thread runs through the series of events unbroken. We must therefore distinctly protest against the idea that by sharply bounding the larger and smaller groups of strata, and the periods corresponding with them, we in any way wish to adopt Cuvier's doctrine of terrestrial revolutions, and of repeated new creations of organic populations. That this erroneous doctrine has long since been completely refuted by Lyell, I have already mentioned. (Compare vol. i. p. 127.)

The five great main divisions of the organic history of the earth, or the palæontological history of development, we call the primordial, primary, secondary, tertiary, and quaternary epochs. Each is distinctly characterized by the predominating development of certain animal and vegetable groups in it, and we might accordingly symbolically designate the five epochs, on the one hand by the names of the groups of the vegetable kingdom, and on the other hand by those of the different classes of vertebrate animals. In this case the *first*, or primordial epoch, would be the era of the Tangles (Algæ) and skull-less Vertebrates; the *second*, or primary epoch, that of the Ferns and Fishes; the *third*, or

secondary epoch, that of Pine Forests and Reptiles; the *fourth*, or tertiary epoch, that of Foliaceous Forests and of Mammals; finally, the *fifth*, or quaternary epoch, the era of Man and his Civilization. The divisions or *periods* which we distinguish in each of the five *long eras* (p. 14) are determined by the different *systems* of strata into which each of the five great *rock-groups* is divided (p. 15). We shall now take a cursory glance at the series of these systems, and at the same time at the populations of the five great epochs.

The first and longest division of the organic history of the earth is formed by the *primordial epoch*, or *the era of the Tangle Forests*. It comprises the immense period from the first spontaneous generation, from the origin of the first terrestrial organism, to the end of the Silurian system of deposits. During this immeasurable space of time, which in all probability was much longer than all the other four epochs taken together, the three most extensive of all the neptunic systems of strata were deposited, namely, the *Laurentian*, upon that the *Cambrian*, and upon that the *Silurian* system. The approximate thickness or size of these three systems together amounts to 70,000 feet. Of these about 30,000 belong to the Laurentian, 18,000 to the Cambrian, and 22,000 to the Silurian system. The average thickness of all the four other rock groups, the primary, secondary, tertiary, and quaternary, taken together, may amount at most to 60,000 feet; and from this fact alone, apart from many other reasons, it is evident that the duration of the primordial period was probably much longer than the duration of all the subsequent periods down to the present day. Many thousands of millions of years were re-

quired to deposit such masses of strata. Unfortunately, by far the largest portion of the primordial group of strata is in the metamorphic state (which we shall directly explain), and consequently the petrifications contained in them—the most ancient and most important of all—have, to a great extent, been destroyed and become unrecognizable. Only in one portion of the Cambrian and Silurian strata have petrifications been preserved in a recognizable condition and in large quantities. The most ancient of all distinctly preserved petrifications has been found in the lowest Laurentian strata (in the Ottawa formation), which I shall afterwards have to speak of as the “Canadian Life’s-dawn” (*Eozoon canadense*).

Although only by far the smaller portion of the primordial or archilithic petrifications are preserved to us in a recognizable condition, still they possess the value of inestimable documents of the most ancient and obscure times of the organic history of the earth. What seems to be shown by them, in the first place, is that during the whole of this immense period there existed only inhabitants of the waters. As yet, at any rate, among all archilithic petrifications, not a single one has been found which can with certainty be regarded as an organism which has lived on land. All the vegetable remains we possess of the primordial period belong to the lowest of all groups of plants, to the class of Tangles or Algæ, living in water. In the warm primæval sea, these constituted the forests of the primordial period, of the richness of which in forms and density we may form an approximate idea from their present descendants, the tangle forests of the Atlantic Sargasso sea. The colossal tangle forests of the archilithic period supplied the place of

the forest vegetation of the mainland, which was then utterly wanting. All the animals, also, whose remains have been found in archilithic strata, like the plants, lived in water. Only crustacea are met with among the animals with articulated feet, as yet no spiders and no insects. Of vertebrate animals, only a very few remains of fishes are known as having been found in the most recent of all primordial strata, in the upper Silurian. But the headless vertebrate animals, which we call *skull-less*, or *Acrania*, and out of which fishes must have been developed, we suppose to have lived in great numbers during the primordial epoch. Hence we may call it after the *Acrania* as well as after the *Tangles*.

The *primary epoch*, or the *era of Fern Forests*, the second main division of the organic history of the earth, which is also called the palæolithic or palæozoic period, lasted from the end of the Silurian formation of strata to the end of the Permian formation. This epoch was also of very long duration, and again falls into three shorter periods, during which three great systems of strata were deposited, namely, first, the *Devonian* system, or the old red sandstone; upon that, the *Carboniferous*, or coal system; and upon this, the *Permian* system. The average thickness of these three systems taken together may amount to about 42,000 feet, from which we may infer the immense length of time requisite for their formation.

The Devonian and Permian formations are especially rich in remains of fishes, of primæval fish as well as enamelled fish (Ganoids), but the bony fish (Teleostei) are absent from the strata of the primary epoch. In coal are found the most ancient remains of animals living on land, both of arti-

culated animals (spiders and insects) as well as of vertebrate animals (amphibious animals, like newts and frogs). In the Permian system there occur, in addition to the amphibious animals, the more highly-developed reptiles, and, indeed, forms nearly related to our lizards (*Proterosaurus*, etc.). But, nevertheless, we may call the primary epoch that of *Fishes*, because these few amphibious animals and reptiles are insignificant in comparison with the immense mass of palæozoic fishes. Just as *Fishes* predominate over the other vertebrate animals, so *Ferns*, or *Filices*, predominate among the plants of this epoch, and, in fact, real ferns and tree ferns (leafed ferns, or *Phylopteridæ*), as well as bamboo ferns (*Calamophytæ*) and scaled ferns (*Lepidophytæ*). These ferns, which grew on land, formed the chief part of the dense palæolithic island forests, the fossil remains of which are preserved to us in the enormously large strata of coal of the Carboniferous system, and in the smaller strata of coal of the Devonian and Permian systems. We are thus justified in calling the primary epoch either the era of *Ferns* or that of *Fishes*.

The third great division of the palæontological history of development is formed by the *secondary epoch*, or the *era of Pine Forests*, which is also called the mesolithic or mesozoic epoch. It extends from the end of the Permian system to the end of the Chalk formation, and is again divided into three great periods. The stratified systems deposited during this period are, first and lowest, the *Triassic* system, in the middle the *Jura* system, and at the top the *Cretaceous* system. The average thickness of these three systems taken together is much less than that of the primary group, and amounts as a whole only to about 15,000

feet. The secondary epoch can accordingly in all probability not have been half so long as the primary epoch.

Just as Fishes prevailed in the primary epoch, *Reptiles* predominated in the secondary epoch over all other vertebrate animals. It is true that during this period the first birds and mammals originated; at that time, also, there existed important amphibious animals, especially the gigantic Labyrinthodonts, in the sea the wonderful sea-dragons, or Halisaurii, swam about, and the first fish with bones were associated with the many primæval fishes (Sharks) and enamelled fish (Ganoïds) of the earlier times; but the very variously developed kinds of reptiles formed the predominating and characteristic class of vertebrate animals of the secondary epoch. Besides those reptiles which were very nearly related to the present living lizards, crocodiles, and turtles, there were, during the mesolithic period, swarms of grotesquely shaped dragons. The remarkable flying lizards, or Pterosaurii, and the colossal land-dragons, or Dinosaurii, of the secondary epoch, are peculiar, as they occur neither in the preceding nor in the succeeding epochs. The secondary epoch may be called the era of *Reptiles*; but on the other hand, it may also be called the era of *Pine Forests*, or more accurately, of the *Gymnosperms*, that is, the epoch of *plants having naked seeds*. For this group of plants, especially as represented by the two important classes—the pines, or *Coniferae*, and the palm-ferns, or *Cycadeæ*—during the secondary epoch constituted a predominant part of the forests. But towards the end of the epoch (in the Chalk period) the plants of the pine tribe gave place to the leaf-bearing forests which then developed for the first time.

The fourth main division of the organic history of the

SURVEY

Of the Palæontological Periods, or of the Greater Divisions of the Organic History of the Earth.

I. *First Epoch* : ARCHILITHIC ERA. *Primordial Epoch.*

(Era of Skull-less Animals and Forests of Tangles.)

- | | | |
|-----------------------------|----|--------------------|
| 1. Older Primordial Period | or | Laurentian Period. |
| 2. Middle Primordial Period | ,, | Cambrian Period. |
| 3. Later Primordial Period | ,, | Silurian Period. |

II. *Second Epoch* : PALÆOLITHIC ERA. *Primary Epoch.*

(Era of Fish and Fern Forests.)

- | | | |
|-------------------------|----|------------------|
| 4. Older Primary Period | or | Devonian Period. |
| 5. Mid Primary Period | ,, | Coal Period. |
| 6. Later Primary Period | ,, | Permian Period. |

III. *Third Epoch* : MESOLITHIC ERA. *Secondary Epoch.*

(Era of Reptiles and Pine Forests.)

- | | | |
|----------------------------|----|---------------|
| 7. Older Secondary Period | or | Trias Period. |
| 8. Middle Secondary Period | ,, | Jura Period. |
| 9. Later Secondary Period | ,, | Chalk Period. |

IV. *Fourth Epoch* : CÆNOLITHIC ERA. *Tertiary Epoch.*

(Era of Mammals and Leaf Forests.)

- | | | |
|----------------------------|----|------------------|
| 10. Older Tertiary Period | or | Eocene Period. |
| 11. Newer Tertiary Period | ,, | Miocene Period. |
| 12. Recent Tertiary Period | ,, | Pliocene Period. |

V. *Fifth Epoch* : ANTHROPOLITHIC ERA. *Quaternary Epoch.*

(Era of Man and Cultivated Forests.)

- | | | |
|------------------------------|----|------------------------|
| 13. Older Quaternary Period | or | Ice or Glacial Period. |
| 14. Newer Quaternary Period | ,, | Post Glacial Period. |
| 15. Recent Quaternary Period | ,, | Period of Culture. |

(The Period of Culture is the Historical Period, or the Period of Tradition.)

SURVEY

Of the Palæontological Formations, or those Strata of the Earth's Crust containing Petrifaactions.

<i>Rock-Groups.</i>	<i>Systems.</i>	<i>Formations.</i>	<i>Synonyms of Formations.</i>
V. <i>Quaternary Group, or Anthropolithic (Anthropozoic) groups of strata</i>	XIV. Recent (Alluvium) XIII. Pleistocene (Diluvium)	{ 36. <i>Present</i> 35. <i>Recent</i> 34. <i>Post glacial</i> 33. <i>Glacial</i>	Upper alluvial Lower alluvial Upper diluvial Lower diluvial
IV. <i>Tertiary Group, or Cænolithic (Cænozoic) groups of strata</i>	XII. Pliocene (Late tertiary) XI. Miocene (New tertiary) X. Eocene (Old tertiary)	{ 32. <i>Arvernian</i> 31. <i>Sub-Appenine</i> 30. <i>Falunian</i> 29. <i>Limburgian</i> 28. <i>Gypsum</i> 27. <i>Nummulitic</i> 26. <i>London clay</i>	Upper pliocene Lower pliocene Upper miocene Lower miocene Upper eocene Mid eocene Lower eocene
III. <i>Secondary Group, or Mesolithie (Mesozoic) groups of strata</i>	IX. Cretaceous VIII. Jura VII. Trias	{ 25. <i>White chalk</i> 24. <i>Green sand</i> 23. <i>Neocomian</i> 22. <i>Wealden</i> 21. <i>Portlandian</i> 20. <i>Oxfordian</i> 19. <i>Bath</i> 18. <i>Lias</i> 17. <i>Keuper</i> 16. <i>Muschelkalk</i> 15. <i>Bunter sand</i>	Upper cretaceous Mid cretaceous Lower cretaceous The Kentish Weald Upper oolite Mid oolite Lower oolite Lias formation Upper trias Mid trias Lower trias
II. <i>Primary Group, or Palæolithie (Palæozoic) groups of strata</i>	VI. Permian V. Carbonic (coal) IV. Devonian (Old red sand-stone)	{ 14. <i>Zechstein</i> 13. 12. <i>Carboniferous sandstone</i> 11. <i>Carboniferous limestone</i> 10. <i>Pilton</i> 9. <i>Ilfracombe</i> 8. <i>Linton</i>	Upper Permian Lower Permian Upper carbonic Lower carbonic Upper Devonian Mid Devonian Lower Devonian
I. <i>Primordial Group, or Archilithic (Archizoic) groups of strata</i>	III. Silurian II. Cambrian I. Laurentian	{ 7. <i>Ludlow</i> 6. <i>Llandovery</i> 5. <i>Llandeilo</i> 4. <i>Potsdam</i> 3. <i>Longmynd</i> 2. <i>Labrador</i> 1. <i>Ottawa</i>	Upper Silurian Mid Silurian Lower Silurian Upper Cambrian Lower Cambrian Upper Laurentian Lower Laurentian

earth, the *tertiary epoch*, or *era of Leafed Forests*, is much shorter and less peculiar than the three first epochs. This epoch, which is also called the *cænolithic* or *cænozoic* epoch, extended from the end of the *cretaceous* system to the end of the *pliocene* system. The strata deposited during it amount only to a thickness of about 3000 feet, and consequently are much inferior to the three first great groups. The three systems also into which the tertiary period is subdivided are very difficult to distinguish from one another. The oldest of them is called *eocene*, or old tertiary; the newer *miocene*, or mid tertiary; and the last is the *pliocene*, or later tertiary system.

The whole population of the tertiary epoch approaches much nearer, on the whole as well as in detail, to that of the present time than is the case in the preceding epochs. From this time the class of *Mammals* greatly predominates over all other vertebrate animals. In like manner, in the vegetable kingdom, the group—so rich in forms—of the *Angiosperms*, or *plants with covered seeds*, predominates, and its *leafy forests* constitute the characteristic feature of the tertiary epoch. The group of the *Angiosperms* consists of the two classes of single-seed-lobed plants, or *Monocotyledons*, and the double-seed-lobed plants, or *Dicotyledons*. The *Angiosperms* of both classes had, it is true, made their appearance in the *Cretaceous* period, and mammals had already occurred in the *Jurassic* period, and even in the *Triassic* period; but both groups, the mammals and the plants with enclosed seeds, did not attain their peculiar development and supremacy until the tertiary epoch, so that it may justly be called after them.

The fifth and last main division of the organic history

of the earth is the *quaternary epoch*, or *era of Civilization*, which in comparison with the length of the four other epochs almost vanishes into nothing, though with a comical conceit we usually call its record the "history of the world." As the period is characterized by the development of *Man* and his *Culture*, which has influenced the organic world more powerfully and with greater transforming effect than have all previous conditions, it may also be called the era of Man, the anthropolithic or anthropozoic period. It might also be called the era of Cultivated Forests, or Gardens, because even at the lowest stage of human civilization man's influence is already perceptible in the utilization of forests and their products, and therefore also in the physiognomy of the landscape. The commencement of this era, which extends down to the present time, is geologically bounded by the end of the pliocene stratification.

The neptunic strata which have been deposited during the comparatively short quaternary epoch are very different in different parts of the earth, but they are mostly of very slight thickness. They are reduced to two "systems," the older of which is designated the *diluvial*, or *pleistocene*, and the later the *alluvial*, or *recent*. The diluvial system is again divided into two "formations," the older *glacial* and the more recent *post glacial* formations. For during the older diluvial period there occurred that extremely remarkable decrease of the temperature of the earth which led to an extensive glaciation of the temperate zones. The great importance which this "ice" or "glacial period" has exercised on the geographical and topographical distribution of organisms has already been explained in the preceding chap-

ter (vol. i. p. 365). But the *post glacial period*, or the more recent diluvial period, during which the temperature again increased and the ice retreated towards the poles, was also highly important in regard to the present state of chorological relations.

The biological characteristic of the quaternary epoch lies essentially in the development and dispersion of the human organism and his culture. Man has acted with a greater transforming, destructive, and modifying influence upon the animal and vegetable population of the earth than any other organism. For this reason, and not because we assign to man a privileged exceptional position in nature in other matters, we may with full justice designate the development of man and his civilization as the beginning of a special and last main division of the organic history of the earth. It is probable indeed that the corporeal development of primæval man out of man-like apes took place as far back as the earlier pliocene period, perhaps even in the miocene tertiary period. But the actual development of *human speech*, which we look upon as the most powerful agency in the development of the peculiar characteristics of man and his dominion over other organisms, probably belongs to that period which on geological grounds is distinguished from the preceding pliocene period as the pleistocene or diluvial. In fact the time which has elapsed from the development of human speech down to the present day, though it may comprise many thousands and perhaps hundreds of thousands of years, almost vanishes into nothing as compared with the immeasurable length of the periods which have passed from the beginning of organic life on the earth down to the origin of the human race.

The tabular view given on page 15 shows the succession of the palæontological rock-groups, systems, and formations, that is, the larger and smaller neptunic groups of strata, which contain petrifications, from the uppermost, or Alluvial, down to the lowest, or Laurentian, deposits. The table on page 14 presents the historical division of the corresponding eras of the larger and smaller palæontological periods, and in a reversed succession, from the most ancient Laurentian up to the most recent Quaternary period.

Many attempts have been made to make an approximate calculation of the number of thousands of years constituting these periods. The thickness of the strata has been compared, which, according to experience, is deposited during a century, and which amounts only to some few lines or inches, with the whole thickness of the stratified masses of rock, the succession of which we have just surveyed. This thickness, on the whole, may on an average amount to about 130,000 feet; of these 70,000 belong to the primordial, or archilithic; 42,000 to the primary, or palæolithic; 15,000 to the secondary, or mesolithic; and finally only 3,000 to the tertiary, or cænolithic group. The very small and scarcely appreciable thickness of the quaternary, or anthropolithic deposit cannot here come into consideration at all. On an average, it may at most be computed as from 500 to 700 feet. But it is self evident that all these measurements have only an average and approximate value, and are meant to give only a rough survey of the *relative* proportion of the systems of strata and of the spaces of time corresponding with them.

Now, if we divide the whole period of the organic history of the earth—that is, from the beginning of life on the earth

down to the present day—into a hundred equal parts, and if then, corresponding to the thickness of the systems of strata, we calculate the relative duration of the time of the five main divisions or periods according to percentages, we obtain the following result :—

I. Archilithic, or primordial period	.	.	.	53.6
II. Palæolithie, or primary period .	.	.	.	32.1
III. Mesolithie, or secondary period	.	.	.	11.5
IV. Cænolithie, or tertiary period .	.	.	.	2.3
V. Anthropolithie, or quaternary period	.	.	.	0.5
Total ...				100.0

According to this, the length of the archilithic period, during which no land-living animals or plants as yet existed, amounts to more than one half, more than 53 per cent.; on the other hand the length of the anthropolithic era, during which man has existed, amounts to scarcely one-half per cent. of the whole length of the organic history of the earth. It is, however, quite impossible to calculate the length of these periods, even approximately, by years.

The thickness of the strata of mud at present deposited during a century, and which has been used as a basis for this calculation, is of course quite different in different parts of the earth under the different conditions in which these deposits take place. It is very slight at the bottom of the deep sea, in the beds of broad rivers with a short course, and in inland seas which receive very scanty supplies of water. It is comparatively great on the sea-shores exposed to strong breakers, at the estuaries of large rivers with long courses, and in inland seas with copious supplies of water. At the mouth of the Mississippi, which carries with it a consider-

able amount of mud, in the course of 100,000 years about 600 feet would be deposited. At the bottom of the open sea, far away from the coasts, during this long period only some few feet of mud would be deposited. Even on the sea-shores where a comparatively large quantity of mud is deposited the thickness of the strata formed during the course of a century may after all amount to no more than a few inches or lines when condensed into solid stone. In any case, however, all calculations based upon these comparisons are very unsafe, and we cannot even approximately conceive the enormous length of the periods which were requisite for the formation of the systems of neptunic strata. Here we can apply only relative, not absolute, measurements of time.

Moreover, we should entirely err were we to consider the size of these systems of strata alone as the measure of the actual space of time which has elapsed during the earth's history. For the elevations and depressions of the earth's crust have perpetually alternated with one another, and the mineralogical and palæontological difference—which is perceived between each two succeeding systems of strata, and between each two of their formations at any particular spot—corresponds in all probability with a considerable intermediate space of many thousands of years, during which that particular part of the earth's crust was raised above the water. It was only after the lapse of this intermediate period, when a new depression again laid the part in question under water, that there occurred a new deposit of earth. As, in the mean time, the inorganic and organic conditions on this part had undergone a considerable transformation, the newly-formed layer of mud was necessarily com-

IV. Tertiary Group of Strata, 3000 feet.	Eocene, Miocene, Pliocene.
III. Mesolithic Group of Strata. Deposits of the Secondary Epoch, about 15,000 feet.	IX. Chalk System. VIII. Jura System. VII. Trias System.
II. Palæolithic Group of Strata. Deposits of the Primary Epoch, about 42,000 feet.	VI. Permian System. V. Coal System. IV. Devonian System.
I. Archilithic Group of Strata. Deposits of the Primordial Epoch, about 70,000 feet.	III. Silurian System, about 22,000 feet. II. Cambrian System, about 18,000 feet. I. Laurentian System, about 30,000 feet.

posed of different earthy constituents and enclosed different petrifications.

The striking differences which so frequently occur between the petrifications of two strata, lying one above another, are to be explained in a simple and easy manner by the supposition that the same part of the earth's surface has been exposed to *repeated depressions and elevations*. Such alternating elevations and depressions take place even now extensively, and are ascribed to the heaving of the fiery fluid nucleus against the rigid crust. Thus, for example, the coast of Sweden and a portion of the west coast of South America are constantly though slowly rising, while the coast of Holland and a portion of the east coast of South America are gradually sinking. The rising as well as the sinking takes place very slowly, and in the course of a century sometimes only amounts to some few lines, sometimes to a few inches, or at most a few feet. But if this action continues uninterruptedly throughout hundreds of thousands of years it is capable of forming the highest mountains.

It is evident that elevations and depressions, such as now can be measured in these places, have uninterruptedly alternated one with another in different places during the whole course of the organic history of the earth. This may be inferred with certainty from the geographical distribution of organisms. (Compare vol. i. p. 350.) But to form a judgment of our palæontological records of creation it is extremely important to show that permanent strata can only be deposited during a slow sinking of the ground under water, but not during its continued rising. When the ground slowly sinks more and more below the level of the

sea, the deposited layers of mud get into continually deeper and quieter water, where they can become condensed into stone undisturbed. But when, on the other hand, the ground slowly rises, the newly-deposited layers of mud, which enclose the remains of plants and animals, again immediately come within the reach of the play of the waves, and are soon worn away by the force of the breakers, together with the organic remains which they enclose. For this simple but very important reason, therefore, abundant layers, in which organic remains are preserved, can only be deposited during a continuous sinking of the ground. When any two different formations or strata, lying one above the other, correspond with two different periods of depression, we must assume a long period of rising between them, of which period we know nothing, because no fossil remains of the then living animals and plants could be preserved. It is evident, however, that these *periods of elevation*, which have passed without leaving any trace behind them, deserve a no less careful consideration than the greater or less alternating *periods of depression*, of whose organic population we can form an approximate idea from the strata containing petrifications. Probably the former were not of shorter duration than the latter.

From this alone it is apparent how imperfect our records must necessarily be, and all the more so since it can be theoretically proved that the variety of animal and vegetable life must have increased greatly during those very periods of elevation. For as new tracts of land are raised above the water, new islands are formed. Every new island, however, is a new centre of creation, because the animals and plants accidentally cast ashore there, find in

the new territory, in the struggle for life, abundant opportunity of developing themselves peculiarly, and of forming new species. This formation of new species has evidently taken place pre-eminently during these intermediate periods, of which, unfortunately, no petrifications could be preserved, whereas, on the contrary, during the slow sinking of the ground there was more chance of numerous species dying out, and of a retrogression into fewer specific forms. The intermediate forms between the old and the newly-forming species must also have lived during the periods of elevation, and consequently could likewise leave no fossil remains.

In addition to the great and deplorable gaps in the palæontological records of creation—which are caused by the periods of elevation—there are, unfortunately, many other circumstances which immensely diminish their value. I must mention here especially the *metamorphic state of the most ancient formations*, of those strata which contain the remains of the most ancient flora and fauna, the original forms of all subsequent organisms, and which, therefore, would be of especial interest. It is just these rocks—and, indeed, the greater part of the primordial, or archilithic strata, almost the whole of the Laurentian, and a large part of the Cambrian systems—which no longer contain any recognizable remains, and for the simple reason that these strata have been subsequently changed or metamorphosed by the influence of the fiery fluid interior of the earth. These deepest neptunic strata of the crust have been completely changed from their original condition by the heat of the glowing nucleus of the earth, and have assumed a crystalline state. In this process, however, the form of

the organic remains enclosed in them has been entirely destroyed. It has been preserved only here and there by a happy chance, as in the case of the most ancient petrifications known, the *Eozoon canadense*, from the lowest Laurentian strata. However, from the layers of crystalline charcoal (graphite) and crystalline limestone (marble), which are found deposited in the metamorphic rocks, we may with certainty conclude that petrified animal and vegetable remains existed in them in earlier times.

Our record of creation is also extremely imperfect from the circumstance that only a small portion of the earth's surface has been accurately investigated by geologists, namely, England, Germany, and France. But we know very little of the other parts of Europe, of Russia, Spain, Italy, and Turkey. In the whole of Europe, only some few parts of the earth's crust have been laid open, by far the largest portion of it is unknown to us. The same applies to North America and to the East Indies. There some few tracts have been investigated; but of the larger portion of Asia, the most extensive of all continents, we know almost nothing; of Africa almost nothing, excepting the Cape of Good Hope and the shores of the Mediterranean; of Australia almost nothing; and of South America but very little. It is clear, therefore, that only quite a small portion, perhaps scarcely the thousandth part of the whole surface of the earth, has been palæontologically investigated. We may therefore reasonably hope, when more extensive geological investigations are made, which are greatly assisted by the constructions of railroads and mines, to find a great number of other important petrifications. A hint that this will be the case is given by the remarkable petrifications found in those parts of Africa and

Asia which have been minutely investigated,—the Cape districts and the Himalaya mountains. A series of entirely new and very peculiar animal forms have become known to us from the rocks of these localities. But we must bear in mind that the vast bottom of the existing oceans is at the present time quite inaccessible to palæontological investigations, and that the greater part of the petrifications which have lain there from primæval times will either never be known to us, or at best only after the course of many thousands of years, when the present bottom of the ocean shall have become accessible by gradual elevation. If we call to mind the fact that three-fifths of the whole surface of the earth consists of water, and only two-fifths of land, it becomes plain that on this account the palæontological record must always present an immense gap.

But, in addition to these, there exists another series of difficulties in the way of palæontology which arises from the nature of the organisms themselves. In the first place, as a rule only the hard and solid parts of organisms can fall to the bottom of the sea or of fresh waters, and be there enclosed in the mud and petrified. Hence it is only the bones and teeth of vertebrate animals, the calcareous shells of molluscs, the chitinous skeletons of articulated animals, the calcareous skeletons of star-fishes and corals, and the woody and solid parts of plants, that are capable of being petrified. But soft and delicate parts, which constitute by far the greater portion of the bodies of most organisms, are very rarely deposited in the mud under circumstances favourable to their becoming petrified, or distinctly impressing their external form upon the hardening mud. Now, it must be borne in mind that large classes of

organisms, as for example the Medusæ, the naked molluscs without shells, a large portion of the articulated animals, almost all worms, and even the lowest vertebrate animals, possess no firm and hard parts capable of being petrified. In like manner the most important parts of plants, such as the flowers, are for the most part so soft and tender that they cannot be preserved in a recognizable form. We therefore cannot expect to find any petrified remains of these important organisms. Moreover, all organisms at an early stage of life are so soft and tender that they are quite incapable of being petrified. Consequently all the petrifications found in the neptunic stratifications of the earth's crust comprise altogether but a very few forms, and of these for the most part only isolated fragments.

We must next bear in mind that the dead bodies of the inhabitants of the sea are much more likely to be preserved and petrified in the deposits of mud than those of the inhabitants of fresh water and of the land. Organisms living on land can, as a rule, become petrified only when their corpses fall accidentally into the water and are buried at the bottom in the hardening layers of mud. But this event depends upon very many conditions. We cannot therefore be astonished that by far the majority of petrifications belong to organisms which have lived in the sea, and that of the inhabitants of the land proportionately only very few are preserved in a fossil state. How many contingencies come into play here we may infer from the single fact that of many fossil mammals, in fact of all the mammals of the secondary, or mesozoic epoch, nothing is known except the lower jawbone. This bone is in the first place comparatively solid, and in the second place very easily separates

itself from the dead body, which floats on the water. Whilst the body is driven away and dissolved by the water, the lower jawbone falls down to the bottom of the water and is there enclosed in the mud. This explains the remarkable fact that in a stratum of limestone of the Jurassic system near Oxford, in the slates of Stonesfield, as yet only the lower jawbones of numerous pouched animals (Marsupials) have been found. They are the most ancient mammals known, and of the whole of the rest of their bodies not a single bone exists. The opponents of the theory of development, according to their usual logic, would from this fact be obliged to draw the conclusion that the lower jawbone was the only bone in the body of those animals.

Footprints are very instructive when we attempt to estimate the many accidents which so arbitrarily influence our knowledge of fossils; they are found in great numbers in different extensive layers of sandstone; for example, in the red sandstone of Connecticut, in North America. These footprints were evidently made by vertebrate animals, probably by reptiles, of whose bodies not the slightest trace has been preserved.* The impressions which their feet have left on the mud alone betray the former existence of these otherwise unknown animals.

The accidents which, besides these, determine the limits of our palæontological knowledge, may be inferred from the fact that we know of only one or two specimens of very many important petrifications. It is not ten years since we became acquainted with the imperfect impression of a bird in the Jurassic or Oolitic system, the knowledge of which

* With the exception of a single specimen of the bones of a foot, preserved in the cabinet of Amherst College.—E. R. L.

has been of the very greatest importance for the phylogeny of the whole class of birds. All birds previously known presented a very uniformly organized group, and showed no striking transitional forms to other vertebrate classes, not even to the nearly related reptiles. But that fossil bird from the Jura possessed not an ordinary bird's tail, but a lizard's tail, and thus confirmed what had been conjectured upon other grounds, namely, the derivation of birds from lizards. This single fossil has thus essentially extended not only our knowledge of the age of the class of birds, but also of their blood relationship to reptiles. In like manner our knowledge of other animal groups has been often essentially modified by the accidental discovery of a single fossil. The palæontological records must necessarily be exceedingly imperfect, because we know of so very few examples, or only mere fragments of very many important fossils.

Another and very sensible gap in these records is caused by the circumstance that the *intermediate forms* which connect the different species have, as a rule, not been preserved, and for the simple reason that (according to the principle of divergence of character) they were less favoured in the struggle for life than the most divergent varieties, which had developed out of one and the same original form. The intermediate links have, on the whole, always died out *rapidly*, and have but rarely been preserved as fossils. On the other hand, the most divergent forms were able to maintain themselves in life for a longer period as independent species, to propagate more numerous, and consequently to be more readily petrified. But this does not exclude the fact that in *some* cases the connecting intermediate forms of the species have been preserved so perfectly petrified, that

even now they cause the greatest perplexity and occasion endless disputes among systematic palæontologists about the arbitrary limits of species.

An excellent example of this is furnished by the celebrated and very variable fresh-water snail from the Stuben Valley, near Steinheim, in Würtemberg, which has been described sometimes as *Paludina*, sometimes as *Valvata*, and sometimes as *Planorbis multiformis*. The snow-white shells of these small snails constitute more than half of the mass of the tertiary limestone hills, and in this one locality show such an astonishing variety of forms, that the most divergent extremes might be referred to at least twenty entirely different species. But all these extreme forms are united by such innumerable intermediate forms, and they lie so regularly above and beside one another, that Hilgendorf was able, in the clearest manner, to unravel the pedigree of the whole group of forms. In like manner, among very many other fossil species (for example, many ammonites, terebratulæ, sea urchins, lily encrinites, etc.) there are such masses of connecting intermediate forms, that they reduce the “dealers in fossil species” to despair.

When we weigh all the circumstances here mentioned, the number of which might easily be increased, it does not appear astonishing that the natural accounts or records of creation formed by petrifications are extremely defective and incomplete. But nevertheless, the petrifications actually discovered are of the greatest value. Their significance is of no less importance to the natural history of creation than the celebrated inscription on the Rosetta stone, and the decree of Canopus, are to the history of nations—to archæology and philology. Just as it has

become possible by means of these two most ancient inscriptions to reconstruct the history of ancient Egypt, and to decipher all hieroglyphic writings, so in many cases a few bones of an animal, or imperfect impressions of a lower animal or vegetable form, are sufficient for us to gain the most important starting-points in the history of the whole group, and in the search after their pedigree. A couple of small back teeth, which have been found in the Keuper formation of the Trias, have of themselves alone furnished a sure proof that mammals existed even in the Triassic period.

Of the incompleteness of the geological accounts of creation, Darwin, agreeing with Lyell, the greatest of all recent geologists, says :—

“ I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines. Each word of the slowly-changing language, more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appear to us to have been abruptly introduced. On this view, the difficulties above discussed are greatly diminished, or even disappear.”—*Origin of Species*, 6th Edition, p. 289.

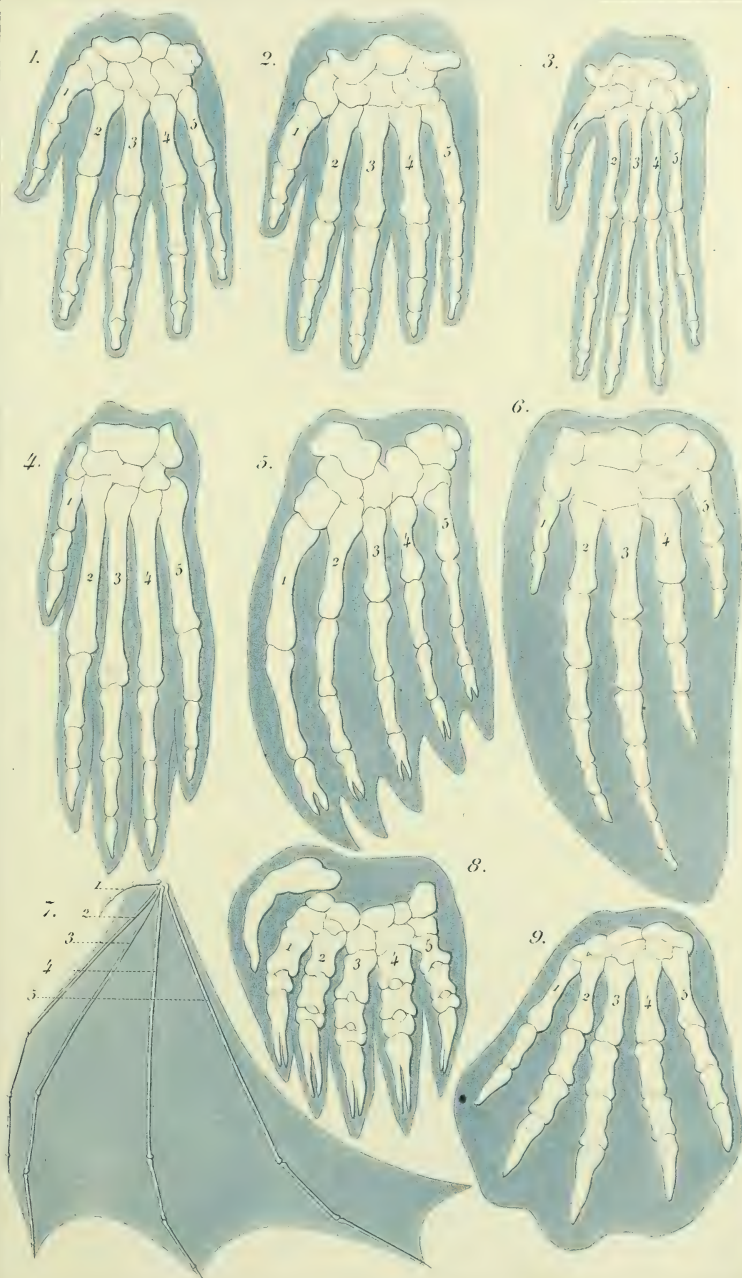
If we bear in mind the exceeding incompleteness of palæontological records, we shall not be surprised that we are still dependent upon so many uncertain hypotheses when actually endeavouring to sketch the pedigree of the different organic groups. However, we fortunately possess, besides

fossils, other records of the history of the origin of organisms, which in many cases are of no less value, nay, in several cases are of much greater value, than fossils. By far the most important of these other records of creation is, without doubt, *ontogeny*, that is, the history of the development of the organic individual (embryology and metamorphology). It briefly repeats in great and marked features the series of forms which the ancestors of the respective individuals have passed through from the beginning of their tribe. We have designated the palæontological history of the development of the ancestors of a living form as the history of a tribe, or *phylogeny*, and we may therefore thus enunciate this exceedingly important *biogenetic fundamental principle*: "*Ontogeny is a short and quick repetition, or recapitulation, of Phylogeny, determined by the laws of Inheritance and Adaptation.*" As every animal and every plant from the beginning of its individual existence passes through a series of different forms, it indicates in rapid succession and in general outlines the long and slowly changing series of states of form which its progenitors have passed through from the most ancient times. (Gen. Morph. ii. 6, 110, 300.)

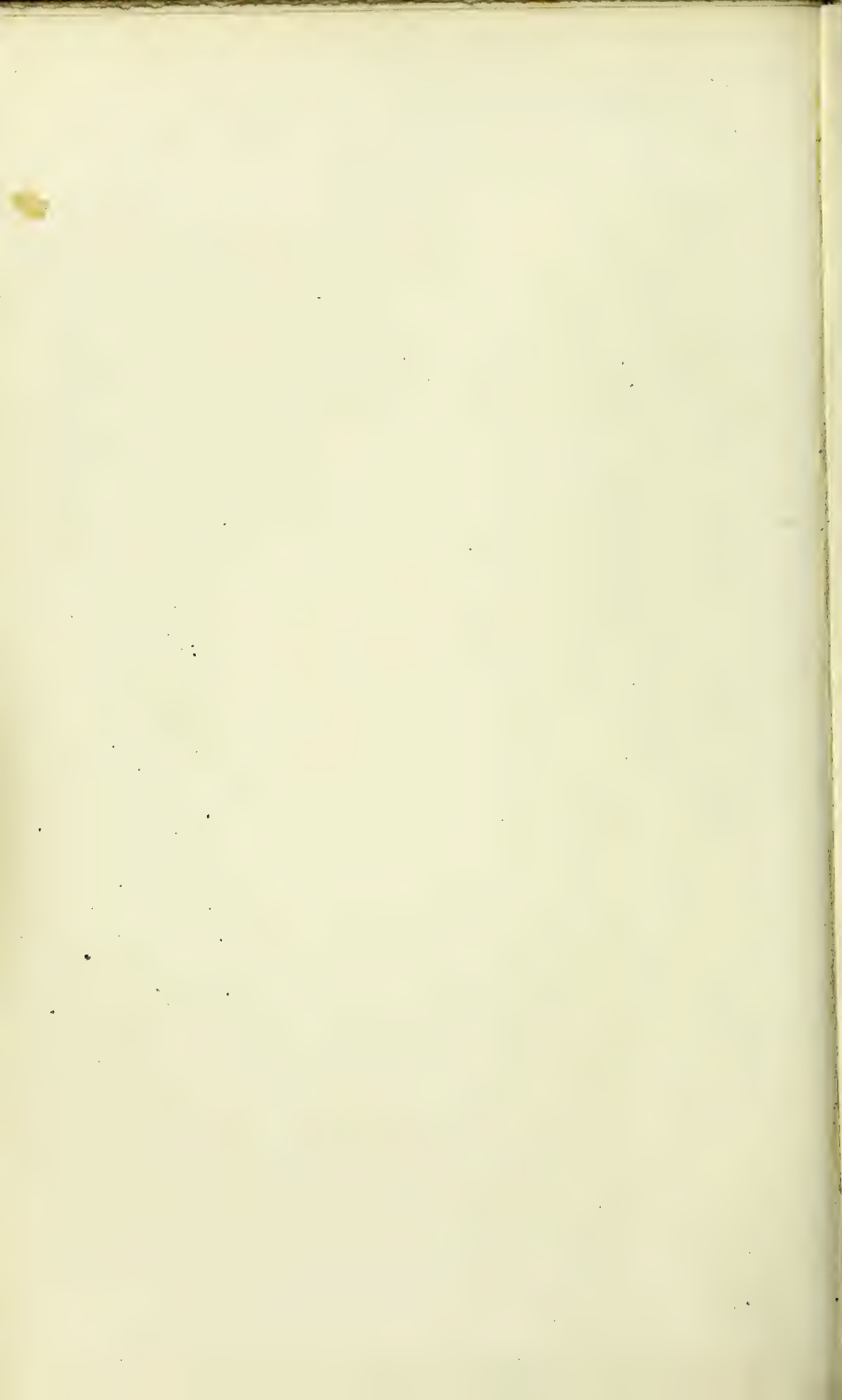
It is true that the sketch which the ontogeny of organisms gives us of their phylogeny is in most cases more or less obscured, and all the more so the more Adaptation, in the course of time, has predominated over Inheritance, and the more powerfully the law of abbreviated inheritance, and the law of correlative adaptation, have exerted their influence. However, this does not lessen the great value which the actual and faithfully preserved features of that sketch possess. *Ontogeny is of the most inestimable value*

for the knowledge of the earliest palæontological conditions of development, just because no petrified remains of the most ancient conditions of the development of tribes and classes have been preserved. These, indeed, could not have been preserved on account of the soft and tender nature of their bodies. No petrifications could inform us of the fundamental and important fact which ontogeny reveals to us, that the most ancient common ancestors of all the different animal and vegetable species were quite simple cells like the egg-cell. No petrification could prove to us the immensely important fact, established by ontogeny, that the simple increase, the formation of cell-aggregates and the differentiation of those cells, produced the infinitely manifold forms of multicellular organisms. Thus ontogeny helps us over many and large gaps in palæontology.

To the invaluable records of creation furnished by palæontology and ontogeny are added the no less important evidences for the blood relationship of organisms furnished by *comparative anatomy*. When organisms, externally very different, nearly agree in their internal structure, one may with certainty conclude that the agreement has its foundation in Inheritance, the dissimilarity its foundation in Adaptation. Compare, for example, the hands and fore paws of the nine different animals which are represented on Plate IV., in which the bony skeleton in the interior of the hand and of the five fingers is visible. Everywhere we find, though the external forms are most different, the same bones, and among them the same number, position, and connection. It will perhaps appear very natural that the hand of *man* (Fig. 1) differs very little from that of the *gorilla* (Fig. 2) and of the *orang-outang* (Fig. 3), his nearest relations. But it will



1. Man, 2. Gorilla, 3. Orang, 4. Dog, 5. Seal
6. Porpoise, 7. Bat, 8. Mole, 9. Duck-bill.



be more surprising if the fore feet of the *dog* also (Fig. 4), as well as the breast-fin (the hand) of the *seal* (Fig. 5), and of the *dolphin* (Fig. 6), show essentially the same structure. And it will appear still more wonderful that even the wing of the *bat* (Fig. 7), the shovel-feet of the *mole* (Fig. 8), and the fore feet of the *duck-bill* (*Ornithorhynchus*) (Fig. 9), the most imperfect of all mammals, is composed of entirely the same bones, only their size and form being variously changed. Their number, the manner of their arrangement and connection has remained the same. (Compare also the explanation of Plate IV., in the Appendix.) It is quite inconceivable that any other cause, except the common inheritance of the part in question from common ancestors, could have occasioned this wonderful homology or similarity in the essential inner structure with such different external forms. Now, if we go down further in the system below the mammals, and find that even the wings of birds, the fore feet of reptiles and amphibious animals, are composed of essentially the same bones as the arms of man and the fore legs of the other mammals, we can, from this circumstance alone, with perfect certainty, infer the common origin of all these vertebrate animals. Here, as in all other cases, the degree of the internal agreement in the form discloses to us the degree of blood relationship.

CHAPTER XVI.

PEDIGREE AND HISTORY OF THE KINGDOM OF THE PROTISTA.

Special Mode of Carrying out the Theory of Descent in the Natural System of Organisms.—Construction of Pedigrees.—Descent of all Many-Celled from Single-Celled Organisms.—Descent of Cells from Monera.—Meaning of Organic Tribes, or Phyla.—Number of the Tribes in the Animal and Vegetable Kingdoms.—The Monophyletic Hypothesis of Descent, or the Hypothesis of one Common Progenitor, and the Polyphyletic Hypothesis of Descent, or the Hypothesis of Many Progenitors.—The Kingdom of Protista, or Primæval Beings.—Eight Classes of the Protista Kingdom—Monera, Amœbæ, or Protoplastæ.—Whip-swimmers, or Flagellata.—Ciliated-balls, or Catallacta.—Labyrinth-streamers, or Labyrinthulæ.—Flint-cells, or Diatomeæ.—Mucous-moulds, or Myxomycetes.—Root-footers (Rhizopoda).—Remarks on the General Natural History of the Protista: Their Vital Phenomena, Chemical Composition, and Formation (Individuality and Fundamental Form).—Phylogeny of the Protista Kingdom.

By a careful comparison of the individual and the palæontological development, as also by the comparative anatomy of organisms, by the comparative examination of their fully developed structural characteristics, we arrive at the knowledge of the degrees of their different structural relationships. By this, however, we at the same time obtain an insight into their true *blood relationship*, which, according to the Theory of Descent, is the real reason of the structural relationship. Hence by collecting, comparing, and

employing the empirical results of embryology, palæontology, and anatomy for supplementing each other, we arrive at an approximate knowledge of "the Natural System," which, according to our views, is the *pedigree* of organisms. It is true that our human knowledge, in all things fragmentary, is especially so in this case, on account of the extreme incompleteness and defectiveness of the records of creation. However, we must not allow this to discourage us, or to deter us from undertaking this highest problem of biology. Let us rather see how far it may even now be possible, in spite of the imperfect state of our embryological, palæontological, and anatomical knowledge, to establish a probable scheme of the genealogical relationships of organisms.

Darwin in his book gives us no answer to these special questions of the Theory of Descent; at the conclusion he only expresses his conjecture "that animals have descended from at most only four or five progenitors, and plants from an equal or less number." But as these few aboriginal forms still show traces of relationship, and as the animal and vegetable kingdoms are connected by intermediate transitional forms, he arrives afterwards at the opinion "that probably all the organic beings which have ever lived on the earth have descended from some one primordial form, into which life was first breathed by the Creator." Like Darwin, all other adherents of the Theory of Descent have only treated it in a general way, and not made the attempt to carry it out specially, and to treat the "Natural System" actually as the pedigree of organisms. If, therefore, we venture upon this difficult undertaking, we must take up independent ground.

Four years ago I set up a number of hypothetical genealogies for the larger groups of organisms in the systematic introduction to my General History of Development (Gen. Morph. vol. ii.), and thereby, in fact, made the first attempt actually to construct the pedigrees of organisms in the manner required by the theory of development. I was quite conscious of the extreme difficulty of the task, and as I undertook it in spite of all discouraging obstacles, I claim no more than the merit of having made the first attempt and given a stimulus for other and better attempts. Probably most zoologists and botanists were but little satisfied with this beginning, and least so in reference to the special domain in which each one is specially at work. However, it is certainly in this case much easier to blame than to produce something better, and what best proves the immense difficulty of this infinitely complicated task is the fact that no naturalist has as yet supplied the place of my pedigrees by better ones. But, like all other scientific hypotheses which serve to explain facts, my genealogical hypotheses may claim to be taken into consideration until they are replaced by better ones.

I hope that this replacement will very soon take place; and I wish for nothing more than that my first attempt may induce very many naturalists to establish more accurate pedigrees for the individual groups, at least in the special domain of the animal and vegetable kingdom which happens to be well known to one or other of them. By numerous attempts of this kind our genealogical knowledge, in the course of time, will slowly advance and approach more and more towards perfection, although it can with certainty be foreseen that we shall never arrive at a

complete pedigree. We lack, and shall ever lack, the indispensable palæontological foundations. The most ancient records will ever remain sealed to us, for reasons which have been previously mentioned. The most ancient organisms which arose by spontaneous generation—the original parents of all subsequent organisms—must necessarily be supposed to have been Monera—simple, soft, albuminous lumps, without structure, without any definite forms, and entirely without any hard and formed parts. They and their next offspring were consequently not in any way capable of being preserved in a petrified condition. But we also lack, for reasons discussed in detail in the preceding chapter, by far the greater portion of the innumerable palæontological documents, which are really requisite for a safe reconstruction of the history of animal tribes, or phylogeny, and for the true knowledge of the pedigree of organisms. If we, therefore, in spite of this, venture to undertake their hypothetical construction, we must chiefly depend for guidance on the two other series of records which most essentially supplement the palæontological archives. These are ontogeny and comparative anatomy.

If thoughtfully and carefully we consult these most valuable records, we at once perceive what is exceedingly significant, namely, that by far the greater number of organisms, especially all higher animals and plants, are composed of a great number of cells, and that they originate out of an egg, and that this egg, in animals as well as in plants, is a single, perfectly simple cell—a little lump of albuminous constitution, in which another albuminous corpuscle, the cell-kernel, is enclosed. This cell containing its kernel grows and becomes enlarged. By division it forms an

accumulation of cells, and out of these, by division of labour (as has previously been described), there arise the numberless different forms which are presented to us in the fully developed animal and vegetable species. This immensely important process—which we may follow step by step, with our own eyes, any day in the embryological development of any animal or vegetable individual, and which as a rule is by no means considered with the reverence it deserves—informs us more surely and completely than all petrifications could do as to the original palæontological development of all many-celled organisms, that is, of all higher animals and plants. For as ontogeny, or the embryological development of every single individual, is essentially only a recapitulation of phylogeny, or the palæontological development of its chain of ancestors, we may at once, with full assurance, draw the simple and important conclusion, that *all many-celled animals and plants were originally derived from single-celled organisms*. The primæval ancestors of man, as well as of all other animals, and of all plants composed of many cells, were simple cells living isolated. This invaluable secret of the organic pedigree is revealed to us with infallible certainty by the egg of animals, and by the true egg-cell of plants. When the opponents of the Theory of Descent assert it to be miraculous and inconceivable that an exceedingly complicated many-celled organism could, in the course of time, have proceeded from a simple single-celled organism, we at once reply that we may see this incredible miracle at any moment, and follow it with our own eyes. For the embryology of animals and plants visibly presents to our eyes in the shortest space of time the same process as that which has taken place in the

origin of the whole tribe during the course of enormous periods of time.

Upon the ground of embryological records, therefore, we can with full assurance maintain that all many-celled, as well as single-celled, organisms are originally descended from simple cells; connected with this, of course, is the conclusion that the most ancient root of the animal and vegetable kingdom was common to both. For the different primæval "original cells" out of which the few different main groups or tribes have developed, only acquired their differences after a time, and were descended from a common "primæval cell." But where did those few "original cells," or the one primæval cell, come from? For the answer to this fundamental genealogical question we must return to the theory of plastids and the hypothesis of spontaneous generation which we have already discussed (vol. i. p. 327).

As was then shown, we cannot imagine *cells* to have arisen by spontaneous generation, but only *Monera*, those primæval creatures of the simplest kind conceivable, like the still living *Protamoebæ*, *Protomyxæ*, etc. (vol. i. p. 186, Fig. 1). only such corpuscles of mucus without component parts—whose whole albuminous body is as homogeneous in itself as an inorganic crystal, but which nevertheless fulfils the two organic fundamental functions of nutrition and propagation—could have directly arisen out of inorganic matter by autogeny at the beginning (we may suppose) of the Laurentian period. While some *Monera* remained at the original simple stage of formation, others gradually developed into cells by the inner kernel of the albuminous mass becoming separated from the external cell-substance. In others, by differentiation of the outermost layer of the cell-substance, an external

covering (membrane, or skin) was formed round simple cytods (without kernel), as well as round naked cells (containing a kernel). By these two processes of separation in the simple primæval mucus of the Moneron body, by the formation of a kernel in the interior and a covering on the outer surface of the mass of plasma, there arose out of the original most simple cytods, or Monera, those four different species of plastids, or individuals, of the first order, from which, by differentiation and combination, all other organisms could afterwards develop themselves. (Compare vol. i. p. 347.)

The question now forces itself upon us, Are all organic cytods and cells, and consequently also those "original cells" which we previously considered to be the primary parents of the few great main groups of the animal and vegetable kingdoms, descended from a single original form of Moneron, or were there several different organic primary forms, each traceable to a peculiar independent species of Moneron which originated by spontaneous generation? In other words, *Is the whole organic world of a common origin, or does it owe its origin to several acts of spontaneous generation?* This fundamental question of genealogy seems at first sight to be of exceeding importance. But on a more accurate examination, we shall soon see that this is not the case, and that it is in reality a matter of very subordinate importance.

Let us now pass on to examine and clearly limit our conception of an *organic tribe*. By *tribe*, or *phylum*, we understand all those organisms of whose blood relationship and descent from a common primary form there can be no doubt, or whose relationship, at least, is most probable from anatomical reasons, as well as from reasons founded on his-

torical development. Our tribes, or phyla, according to this idea, essentially coincide with those few "great classes," or "main classes," of which Darwin also thinks that each contains only organisms related by blood, and of which, both in the animal and in the vegetable kingdoms, he only assumes either four or five. In the animal kingdom these tribes would essentially coincide with those four, five, or six main divisions which zoologists, since Bär and Cuvier, have distinguished as "main forms, general plans, branches, or sub-kingdoms" of the animal kingdom. (Compare vol. i. p. 53.) Bär and Cuvier distinguished only four of them, namely :—1. The vertebrate animals (Vertebrata); 2. The articulated animals (Articulata); 3. The molluscous animals (Mollusca); and 4. The radiated animals (Radiata). At present six are generally distinguished, since the tribe of the articulated animals is divided into two tribes, those possessing articulated feet (Arthropoda), and the worms (Vermes); and in like manner the tribe of radiated animals is subdivided into the two tribes of the star animals (Echinodermata) and the animal-plants (Zoophyta). Within each of these six tribes, all the included animals, in spite of great variety in external form and inner structure, nevertheless possess such numerous and important characteristics in common, that there can be no doubt of their blood relationship. The same applies also to the six great main classes which modern botany distinguishes in the vegetable kingdom, namely :—1. Flowering plants (Phanerogamia); 2. Ferns (Filicinæ); 3. Mosses (Muscinæ); 4. Lichens (Lichenes); 5. Fungi (Fungi); and 6. Water-weeds (Algæ). The last three groups, again, show such close relations to one another, that by the name of "Thallus plants" they may be contrasted with the three first main classes, and consequently

the number of phyla, or main groups, of the vegetable kingdom may be reduced to the number of four. Mosses and ferns may likewise be comprised as "Prothallus plants" (Prothallophyta), and thereby the number of plant tribes reduced to three—Flowering plants, Prothallus plants, and Thallus plants.

Very important facts in the anatomy and the history of development, both in the animal and vegetable kingdoms, support the supposition that even these few main classes or tribes are connected at their roots, that is, that the lowest and most ancient primary forms of all three are related by blood to one another. Nay, by a further examination we are obliged to go still a step further, and to agree with Darwin's supposition, that even the two pedigrees of the animal and vegetable kingdom are connected at their lowest roots, and that the lowest and most ancient animals and plants are derived from a single common primary creature. According to our view, this common primæval organism can have been nothing but a Moneron which took its origin by spontaneous generation.

In the mean time we shall at all events be acting cautiously if we avoid this last step, and assume true blood relationship only within each tribe, or phylum, where it has been undeniably and surely established by facts in comparative anatomy, ontogeny, and phylogeny. But we may here point to the fact that two different fundamental forms of genealogical hypothesis are possible, and that all the different investigations of the Theory of Descent in relation to the origin of organic groups of forms will, in future, tend more and more in one or the other of these directions. The unitary, or *monophyletic*, hypothesis of descent will endeavour

to trace the first origin of all individual groups of organisms, as well as their totality, to a single common species of Moneron which originated by spontaneous generation (vol. i. p. 343). The multiple, or *polyphyletic*, hypothesis of descent, on the other hand, will assume that several different species of Monera have arisen by spontaneous generation, and that these gave rise to several different main classes (tribes, or phyla) (vol. i. p. 348). The apparently great contrast between these two hypotheses is in reality of very little importance. For both the monophyletic and the polyphyletic hypothesis of descent must necessarily go back to the Monera as the most ancient root of the one or of the many organic tribes. But as the whole body of a Moneron consists only of a simple, formless mass, without component particles, made up of a single albuminous combination of carbon, it follows that the differences of the different Monera can only be of a chemical nature, and can only consist in a different atomic composition of that mucous albuminous combination. But these subtle and complicated differences of mixture of the infinitely manifold combinations of albumen are not appreciable by the rude and imperfect means of human observation, and are, consequently, at present of no further interest to the task we have in hand.

The question of the monophyletic or polyphyletic origin will constantly recur within each individual tribe, where the origin of a smaller or of a larger group is discussed. In the vegetable kingdom, for example, some botanists will be inclined to derive all flowering plants from a single form of fern, while others will prefer the idea that several different groups of Phanerogama have sprung from several different groups of ferns. In like manner, in the animal kingdom,

some zoologists will be more in favour of the supposition that all placental animals are derived from a single pouched animal; others will be more in favour of the opposite supposition, that several different groups of placental animals have proceeded from several different pouched animals. In regard to the human race itself, some will prefer to derive it from a single form of ape, while others will be more inclined to the idea that several different races of men have arisen, independently of one another, out of several different species of ape. Without here expressing our opinion in favour of either the one or the other conception, we must, nevertheless, remark that in general *the monophyletic hypothesis of descent deserves to be preferred to the polyphyletic hypothesis of descent*. In accordance with the chorological proposition of a single "centre of creation" or of a single primæval home for most species (which has already been discussed), we may be permitted to assume that the original form of every larger or smaller natural group only originated *once* in the course of time, and only in *one part* of the earth. We may safely assume this simple original root, that is, the monophyletic origin, in the case of all the more highly developed groups of the animal and vegetable kingdoms. (Compare vol. i. p. 353). But it is very possible that the more complete Theory of Descent of the future will involve the polyphyletic origin of very many of the low and imperfect groups of the two organic kingdoms.

For these reasons I consider it best, in the mean time, to adopt the *monophyletic hypothesis of descent* both for the animal and for the vegetable kingdom. Accordingly, the above-mentioned six tribes, or phyla, of the animal kingdom

must be connected at their lowest root, and likewise the three or six main classes, or phyla, of the vegetable kingdom must be traced to a common and most ancient original form. How the connection of these tribes is to be conceived I shall explain in the succeeding chapters. But before proceeding to this, we must occupy ourselves with a very remarkable group of organisms, which cannot without artificial constraint be assigned either to the pedigree of the vegetable or to that of the animal kingdom. These interesting and important organisms are the *primary creatures*, or *Protista*.

All organisms which we comprise under the name of Protista show in their external form, in their inner structure, and in all their vital phenomena, such a remarkable mixture of animal and vegetable properties, that they cannot with perfect justice be assigned either to the animal or to the vegetable kingdom; and for more than twenty years an endless and fruitless dispute has been carried on as to whether they are to be assigned to this or that kingdom. Most of the Protista are so small that they can scarcely, if at all, be perceived with the naked eye. Hence the majority of them have only become known during the last fifty years, since by the help of the improved and general use of the microscope these minute organisms have been more frequently observed and more accurately examined. However, no sooner were they better known than endless disputes arose about their real nature and their position in the natural system of organisms. Many of these doubtful primary creatures botanists defined as animals, and zoologists as plants; neither of the two would own them. Others, again, were declared by botanists to be plants, and by zoologists to be animals; each claimed them. These contra-

ditions are not altogether caused by our imperfect knowledge of the Protista, but in reality by their true nature. Indeed, most Protista present such a confused mixture of several animal and vegetable characteristics, that each investigator may arbitrarily assign them either to the animal or vegetable kingdom. Accordingly as he defines these two kingdoms, and as he looks upon this or that characteristic as determining the animal or vegetable nature, he will assign the individual classes of Protista in one case to the animal and in another to the vegetable kingdom. But this systematic difficulty has become an inextricable knot by the fact that all more recent investigations on the lowest organisms have completely effaced, or at least destroyed, the sharp boundary between the animal and vegetable kingdom which had hitherto existed, and to such a degree that its restoration is possible only by means of a completely artificial definition of the two kingdoms. But this definition could not be made so as to apply to many of the Protista.

For this and other reasons it is, in the mean time, best to exclude the doubtful beings from the animal as well as from the vegetable kingdom, and to comprise them in a third organic kingdom standing midway between the two others. This intermediate kingdom I have established as the *Kingdom of the Primary Creatures* (Protista), when discussing general anatomy in the first volume of my *General Morphology*, p. 191-238. In my *Monograph of the Monera*,¹⁵ I have recently treated of this kingdom, having somewhat changed its limits, and given it a more accurate definition. Of independent classes of the kingdom Protista, we may at present distinguish the following:—

1. The still living Monera ; 2. The Amœboidea, or Protoplasts ; 3. The Whip-swimmers, or Flagellata ; 4. The Flimmer-balls, or Catallacta ; 5. The Tram-weavers, or Labyrinthuleæ ; 6. The Flint-cells, or Diatomeæ ; 7. The Slime-moulds, or Myxomycetes ; 8. The Ray-streamers, or Rhizopoda.

The most important groups at present distinguishable in these eight classes of Protista are named in the systematic table on p. 51. Probably the number of these Protista will be considerably increased in future days by the progressive investigations of the ontogeny of the simplest forms of life, which have only lately been carried on with any great zeal. With most of the classes named we have become intimately acquainted only during the last ten years. The exceedingly interesting Monera and Labyrinthuleæ, as also the Catallacta, were indeed discovered only a few years ago. It is probable also that very numerous groups of Protista have died out in earlier periods, without having left any fossil remains, owing to the very soft nature of their bodies. We might add to the Protista from the still living lowest groups of organisms—the Fungi ; and in so doing should make a very large addition to its domain. Provisionally we shall leave them among plants, though many naturalists have separated them altogether from the vegetable kingdom.

The pedigree of the kingdom Protista is still enveloped in the greatest obscurity. The peculiar combination of animal and vegetable properties, the indifferent and uncertain character of their relations of forms and vital phenomena, together with a number of several very peculiar features which separate most of the subordinate classes sharply from the others, at present baffle every attempt distinctly to make out their blood relationships with one

another, or with the lowest animals on the one hand, and with the lowest plants on the other hand. It is not improbable that the classes specified, and many other unknown classes of Protista, represent quite independent organic tribes, or phyla, each of which has independently developed from one, perhaps from various, Monera which have arisen by spontaneous generation. If we do not agree to this polyphyletic hypothesis of descent, and prefer the monophyletic hypothesis of the blood relationship of all organisms, we shall have to look upon the different classes of Protista as the lower small offshoots of the root, springing from the same simple Monera root, out of which arose the two mighty and many-branched pedigrees of the animal kingdom on the one hand, and of the vegetable kingdom on the other. (Compare pp. 74, 75.) Before I enter into this difficult question more accurately, it will be appropriate to premise something further as to the contents of the classes of Protista given on the next page, and their general natural history.

It will perhaps seem strange that I should here again begin with the remarkable *Monera* as the first class of the Protista kingdom, as I of course look upon them as the most ancient primary forms of all organisms without exception. Still, what are we otherwise to do with the *still living Monera*? We know nothing of their palæontological origin, we know nothing of any of their relations to lower animals or plants, and we know nothing of their possible capability of developing into higher organisms. The simple and homogeneous little lump of slime or mucus which constitutes their entire body (Fig. 8) is the most ancient and original form of animal as well as of vegetable plastids. Hence it would evidently be just as arbitrary and unreason-

SYSTEMATIC SURVEY

Of the Larger and Smaller Groups of the Kingdom Protista.

<i>Classes of the Protista Kingdom.</i>	<i>Systematic Name of the Classes.</i>	<i>Orders of Families of the Classes.</i>	<i>A name of a Genus as an example.</i>
1. MONERS	Monera	{ 1. Gymnomonera 2. Lepomonera	Protogenes Protomyxa
2. PROTOPLASTS	Amœboida	{ 1. Gymnamœbæ 2. Lepamœbæ 3. Gregarinæ	Amœba Arcella Monocystis
3. WHIP-SWIM- MERS	Flagellata	{ 1. Nudiſſagellata 2. Cilioſſagellata	Euglena Peridinium
4. FLIMMER-BALLS			Magosphæra
5. TRAM-WEAVERS	Labyrinthulæ	1. Labyrinthulæ	Labyrinthula
6. FLINT-CELLS	Diatomea	{ 1. Striata 2. Vittata 3. Areolata	Navicula Tabellaria Coscinodiscus
7. SLIME-MOULDS	Myxomycetes	{ 1. Physaræ 2. Stemonitæ 3. Trichiaceæ 4. Lycogalæ	Æthaliuſ Stemonitis Arcyria Reticularia
8. RAY-STREAM- ERS, OR RHIZOPODS. (Root-feet.)	{ I. Acyrtaria II. Heliozoa III. Radiolaria	{ 1. Monothalamia 2. Polythalamia	Gromia Nummulina
		1. Heliozoa	Actinosphæriuſ
		{ 1. Monocyrtaria 2. Polycyrtaria	Cyrtidoſphæra
			Colloſphæra

able to assign them to the animal as it would be to assign them to the vegetable kingdom. In any case we shall for the present be acting more cautiously and critically if we comprise the still living Monera—whose number and distribution is probably very great—as a special and independent class, contrasting them with the other classes of the kingdom Protista, as well as with the animal kingdom. Morphologically considered, the Monera—on account of the perfect homogeneity of the albuminous substance of their

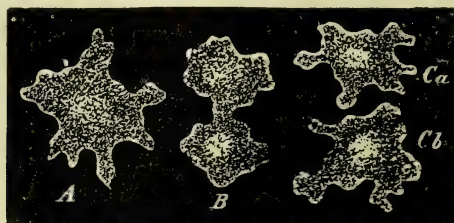


FIG. 8.—*Protamoeba primitiva*, a fresh-water Moneron, much enlarged. A. The entire Moneron with its form-changing processes. B. It begins to divide itself into two halves. C. The division of the two halves is completed, and each now represents an independent individual.

bodies, on account of their utter want of heterogeneous particles—are more closely connected with anorgana than with organisms, and evidently form the transition between the inorganic and organic world of bodies, as is necessitated by the hypothesis of spontaneous generation. I have described and given illustrations of the forms and vital phenomena of the still living Monera (*Protamoeba*, *Protophyes*, *Protomyxa*, etc.) in my Monograph of the Monera,¹⁵ and have briefly mentioned the most important facts in the eighth chapter (vol. i. pp. 183–187). Therefore, only by way of a specimen, I here repeat the drawing of the fresh-

water *Protamœba* (Fig. 8). The history of the life of an orange-red *Protomyxa adrantiaca*, which I observed at Lanzerote, one of the Canary Islands, is given in Plate I. (see its explanation in the Appendix). Besides this, I here add a drawing of the form of *Bathybius*, that remarkable Moneron discovered by Huxley, which lives in the greatest depths of the sea in the shape of naked lumps of protoplasm and reticular mucus (vol. i. p. 344).



FIG. 9. — *Bathybius Hæckeli*, the "creature of primæval slime," from the greatest depths of the sea. The figure, which is greatly magnified, only shows that form of the *Bathybius* which consists of a naked network of protoplasm, without the discoliths and cyatholiths which are found in other forms of the same Moneron, and which perhaps may be considered as the products of its secretion.

The *Amœbæ* of the present day, and the organisms most closely connected with them, *Arcellidæ* and *Gregarinæ*, which we here unite as a second class of Protista under the name of *Amœboidea* (Protoplasta), present no fewer genealogical difficulties than the Monera. These primary creatures are at present usually placed in the animal kingdom without its in reality being understood why. For simple naked cells—that is, shell-less plastids with a kernel—occur as well among real plants as real animals. The generative cells, for example, in many *Algæ* (spores and eggs) exist for a longer or shorter time in water in the

form of naked cells with a kernel, which cannot be distinguished at all from the naked eggs of many animals (for example, those of the Siphonophorous Medusæ). (Compare the figure of a naked egg of a bladder-wrack in Chapter xvii. p. 90). In reality every naked simple cell, whether it proceeds from an animal or vegetable body, cannot be distinguished from an independent Amœba. For an Amœba is nothing but a simple primary cell, a naked little lump of cell-matter, or plasma, containing a kernel. The contractility of this plasma, which the free Amœba shows in stretching out and drawing in its changing processes, is a general vital property of the organic plasma of all animal as well as of all vegetable plastids. When a freely moving Amœba, which perpetually changes its form, passes into a state of rest, it draws itself together into the form of a globule, and surrounds itself with a secreted membrane. It can then be as little distinguished from an animal egg as from a simple globular vegetable cell. (Fig. 10 A).

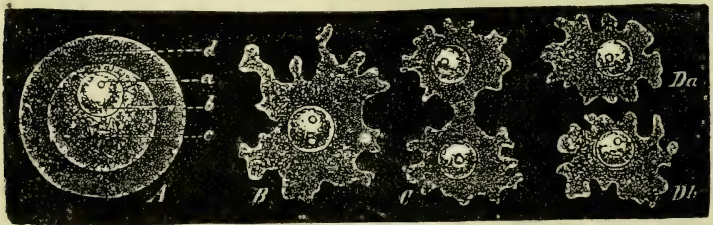


FIG. 10.—Amœba sphærococcus, greatly magnified. A fresh-water Amœba without a contractile vacuole. A. The enclosed Amœba in the state of a globular lump of plasma (c) enclosing a kernel and a kernel-speck (a). The simple cell is surrounded by a cyst, or cell-membrane (d). B. The free Amœba, which has burst and left the cyst, or cell-membrane. C. It begins to divide by its kernel parting into two kernels, and the cell-substance between the two contracting. D. The division is completed, and the cell-substance has entirely separated into two bodies. (Da and Db).

Naked cells, with kernels, like those represented in Fig. 10 *B*, which are continuously changing, stretching out and drawing in formless, finger-like processes, and which are on this account called amœboid, are found frequently and widely dispersed in fresh water and in the sea; nay, are even found creeping on land. They take their food in the same way as was previously described in the case of the *Protamœba* (vol. i. p. 186). Their propagation by division can sometimes be observed (Fig. 10 *C, D*.) I have described the processes in an earlier chapter (vol. i. p. 187). Many of these formless Amœbæ have lately been recognized as the early stages of development of other Protista (especially the *Myxomycetæ*), or as the freed cells of lower animals and plants. The colourless blood-cells of animals, for example, those of human blood, cannot be distinguished from Amœbæ. They, like the latter, can receive solid corpuscles into their interior, as I was the first to show by feeding them with finely divided colouring matters (Gen. Morph. i. 271). However, other Amœbæ (like the one given in Fig. 10) seem to be independent "good species," since they propagate themselves unchanged throughout many generations. Besides the real, or *naked*, Amœbæ (*Gymnamœbæ*), we also find widely diffused in fresh water *case-bearing* Amœbæ (*Lep-amœbæ*), whose naked plasma body is *partially* protected by a more or less solid shell (*Arcella*), sometimes even by a case (*Diffugia*) composed of small stones. Lastly, we frequently find in the body of many lower animals parasitic Amœbæ (*Gregarinæ*), which, adapting themselves to a parasitic life, have surrounded their plasma-body with a delicate closed membrane.

The simple naked Amœbæ are, next to the Monera, the

most important of all organisms to the whole science of biology, and especially to general genealogy. For it is evident that the Amœbæ originally arose out of simple Monera (Protamœbæ), by the important process of segregation taking place in their homogeneous viscid body—the differentiation of an inner kernel from the surrounding plasma. By this means the great progress from a simple cytod (without kernel) into a real cell (with kernel) was accomplished (compare Fig. 8 *A* and Fig. 10 *B*). As some of these cells at an early stage encased themselves by secreting a hardened membrane, they formed the first vegetable cells, while others, remaining naked, developed into the first aggregates of animal cells. The presence or absence of an encircling hard membrane forms the most important, although by no means the entire, difference of form between animal and vegetable cells. As vegetable cells even at an early stage enclose themselves within their hard, thick, and solid cellular shell, like that of the Amœbæ in a state of rest (Fig. 10 *A*), they remain more independent and less accessible to the influences of the outer world than are the soft animal cells, which are in most cases naked, or merely covered by a thin pliable membrane. But in consequence of this the vegetable cells cannot combine, as do the animal cells, for the construction of higher and composite fibrous tracts, for example, the nervous and muscular tissues. It is probable that, in the case of the most ancient single-celled organisms, there must have developed at an early stage the very important difference in the animal and vegetable mode of receiving food. The most ancient single-celled animals, being naked cells, could admit solid particles into the interior of their soft bodies, as do the Amœbæ (Fig. 10 *B*) and the

colourless blood-cells; whereas the most ancient single-celled plants encased by their membranes were no longer able to do this, and could admit through it only fluid nutrition (by means of diffusion).

The *Whip-swimmers* (Flagellata), which we consider as a third class of the kingdom Protista, are of no less doubtful nature than the Amœbæ. They often show as close and important relations to the vegetable as to the animal kingdom. Some Flagellata at an early stage, when freely moving about, cannot be distinguished from real plants, especially from the spores of many Algæ; whereas others are directly allied to real animals, namely, to the fringed



FIG. 11.—A single Whip-swimmer (*Euglena striata*), greatly magnified. Above a thread-like lashing whip is visible; in the centre the round cellular kernel, with its kernel speck.

Infusoria (Ciliata). The Flagellata are simple cells which live in fresh or salt water, either singly or united in colonies. The characteristic part of their body is a very movable simple or compound whip-like appendage (whip, or flagellum) by means of which they actively swim about in the water. This class is divided into two orders. Among the fringed whip-swimmers (Cilioflagellata) there exists, in addition to the long whip, a short fringe of vibrating hairs, which is wanting in the unfringed whip-swimmers (Nudoflagellata). To the former belong the flint-shelled yellow *Peridinia*, which are largely active in causing the phosphorescence of the sea; to the latter belong the green *Euglenæ*, immense masses of which frequently make our ponds in spring quite green.

A very remarkable new form of Protista, which I have named *Flimmer-ball* (*Magosphæra*), I discovered only three years ago (in September, 1869), on the Norwegian coast (Fig. 12), and have more accurately described in my



FIG. 12.—The Norwegian Flimmer-ball (*Magosphæra planula*) swimming by means of its vibratile fringes, as seen from the surface.

Biological Studies¹⁵ (p. 137, Plate V.). Off the island of Gis-oe, near Bergen, I found swimming about, on the surface of the sea, extremely neat

little balls composed of a number (between thirty and forty) of fringed pear-shaped cells, the pointed ends of which were united in the centre like radii. After a time the ball dissolved. The individual cells swarmed about independently in the water like fringed Infusoria, or Ciliata. These afterwards sank to the bottom, drew their fringes into their bodies, and gradually changed into the form of creeping Amœbæ (like Fig. 10 *B*). These last afterwards encased themselves (as in Fig. 10 *A*), and then divided by repeated halvings into a large number of cells (exactly as in the case of the cleavage of the egg, Fig. 6, vol. i. p. 299). The cells became covered with vibratile hairs, broke through the case enclosing them, and now again swam about in the shape of a fringed ball (Fig. 12). This wonderful organism, which sometimes appears like a simple Amœba, sometimes as a

single fringed cell, sometimes as a many-celled fringed ball, can evidently be classed with none of the other Protista, and must be considered as the representative of a new independent group. As this group stands midway between several Protista, and links them together, it may bear the name of *Mediator*, or *Catallacta*.

The Protista of the fifth class, the *Tram-weavers*, or *Labyrinthuleæ*, are of a no less puzzling nature; they were lately discovered by Cienkowski on piles in sea water (Fig. 13). They are spindle-shaped cells, mostly of a yellow-

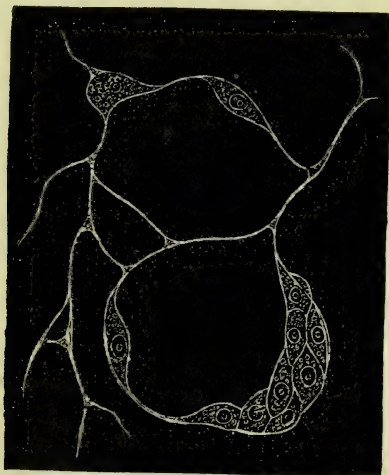


FIG. 13.—*Labyrinthula macrocystis* (much enlarged). Below is a large group of accumulated cells, one of which, on the left, is separating itself; above are two single cells which are gliding along the threads of the retiform labyrinth which form their "tramways."

ochre colour, which are sometimes united into a dense mass, sometimes move about in a very peculiar way. They form, in a manner not yet explained, a retiform frame of entangled threads (compared to a labyrinth), and on the dense filamentous "tramways" of this frame they glide about. From the shape of the cells of the *Labyrinthuleæ* we might consider them as the simplest plants, from their motion as the simplest animals, but in reality they are neither animals nor plants.

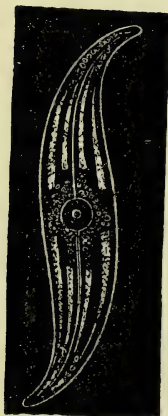


FIG. 14.—*Navicula hippocampus* (greatly magnified). In the middle of the cell the cell-kernel (nucleus) is visible, together with its kernel speck (nucleolus).

The *Flint-cells* (Diatomeæ), a sixth class of Protista, are perhaps the most closely related to the *Labyrinthuleæ*. These primary creatures—which at present are generally considered as plants, although some celebrated naturalists still look upon them as animals—inhabit the sea and fresh waters in immense masses, and offer an endless variety of the most elegant forms. They are mostly small microscopic cells, which either live singly (Fig. 14), or united in great numbers, and occur either attached to objects, or glide and creep about in a peculiar manner. Their soft cell-substance, which is of a characteristic brownish yellow colour, is always enclosed by a solid and hard flinty shell, possessing the neatest and most varied forms. This flinty covering is open to the exterior only by one or two slits, through which the enclosed soft plasma-body communicates with the outer world. The flinty cases are found petrified in masses, and many rocks—for example, the Tripoli slate polish, the Swedish mountain meal, etc.,—are in a great measure composed of them.

A seventh class of Protista is formed by the remarkable *Slime-moulds* (Myxomycetes). They were formerly universally considered as plants, as real Fungi, until ten years ago the botanist De Bary, by discovering their ontogeny, proved them to be quite distinct from Fungi, and rather to be akin to the lower animals. The mature body is a



FIG. 15.—A stalked fruit-body (spore-bladder, filled with spores) of one of the Myxomycetes (*Physarum albipes*) not much enlarged.

roundish bladder, often several inches in size, filled with fine spore-dust and soft flakes (Fig. 15), as in the case of the well-known puff-balls (*Gastromycetes*). However, the characteristic cellular threads, or hyphæ, of a real fungus do not arise from

the germinal corpuscles, or spores, of the Myxomycetes, but merely naked masses of plasma, or cells, which at first swim about in the form of *Flagellata* (Fig. 11), afterwards creep about like the *Amœbæ* (Fig. 10 *B*), and finally combine with others of the same kind to form large masses of "slime," or "plasmodia." Out of these, again, there arises, by-and-by, the bladder-shaped fruit-body. Many of my readers probably know one of these plasmodia, the *Æthelium septicum*, which in summer forms a beautiful yellow mass of soft mucus, often several feet in breadth, known by the name of "tan flowers," and penetrates tan-heaps and tan-beds. At an early stage these slimy, freely-creeping Myxomycetes, which live for the most part in damp forests, upon decaying vegetable substances, bark of trees, etc., are with equal justice or injustice declared by zoologists to be animals, while in the mature, bladder-shaped condition of fructification they are by botanists defined as plants.

The nature of the *Ray-streamers* (*Rhizopoda*), the eighth class of the kingdom *Protista*, is equally obscure. These remarkable organisms have peopled the sea from the most ancient times of the organic history of the earth, in an

immense variety of forms, sometimes creeping at the bottom of the sea, sometimes swimming on the surface. Only very few live in fresh water (*Gromia*, *Actinosphærium*). Most of them possess solid calcareous or flinty shells of an extremely beautiful construction, which can be perfectly preserved in a fossil state. They have frequently accumulated in such huge numbers as to form mountain masses, although the single individuals are very small, and often scarcely visible, or completely invisible, to the naked eye. A very few attain the diameter of a few lines, or even as much as a couple of inches. The name which the class bears is given because thousands of exceedingly fine threads of protoplasm radiate from the entire surface of their naked slimy body; these rays are quasi-feet, or pseudopodia, which branch off like roots (whence the term *Rhizopoda*, signifying root-footed), unite like nets, and are observed continually to change form, as in the case of the simpler plasmic feet of the *Amœboidea*, or *Protoplasts*. These ever-changing little pseudo-feet serve both for locomotion and for taking food.

The class of the *Rhizopoda* is divided into three different legions, viz. the chamber-shells, or *Acyttaria*, the sun-animals, or *Heliozoa*, and the basket-shells, or *Radiolaria*. The *Chamber-shells* (*Acyttaria*) constitute the first and lowest of these three legions; for the whole of their soft body consists merely of simple mucous or slimy cell-matter, or protoplasm, which has not differentiated into cells. However, in spite of this most primitive nature of body, most of the *Acyttaria* secrete a solid shell composed of calcareous earth, which presents a great variety of exquisite forms. In the more ancient and more simple *Acyttaria* this shell is a simple chamber, bell-shaped, tubular, or like the shell of

a snail, from the mouth of which a bundle of plasmic threads issues. In contrast to these *single-chambered forms* (Monothalamia), the *many-chambered forms* (Polythalamia)—to which the great majority of the Acyttaria belong—possess a house, which is composed in an artistic manner of numerous chambers. These chambers sometimes lie in a row one behind the other, sometimes in concentric circles or spirals, in the form of a ring round a central point, and then frequently one above another in many tiers, like the boxes of an amphitheatre. This formation, for example, is found in the nummulites, whose calcareous shells, of the size of a lentil, have accumulated to the number of millions, and form whole mountains on the shores of the Mediterranean. The stones of which some of the Egyptian pyramids are built consist of such nummulitic limestone. In most cases the chambers of the shells of the Polythalamia are wound round one another in a spiral line. The chambers are connected with one another by passages and doors, like rooms of a large palace, and are generally open towards the outside by numerous little windows, out of which the plasmic body can stream or strain forth its little pseudo-feet, or rays of slime, which are always changing form. But in spite of the exceedingly complicated and elegant structure of this calcareous labyrinth, in spite of the endless variety in the structure and the decoration of its numerous chambers, and in spite of the regularity and elegance of their execution, the whole of this artistic palace is found to be the secreted product of a perfectly formless, slimy mass, devoid of any component parts! Verily, if the whole of the recent anatomy of animal and vegetable textures did not support our theory of plastids, if all its important results did not

unanimously corroborate the fact that the whole miracle of vital phenomena and vital forms is traceable to the active agency of the formless albuminous combinations of protoplasm, the Polythalamia alone would secure the triumph of that theory. For we may here at any moment, by means of the microscope, point out the wonderful fact, first established by Dujardin and Max Schulze, that the formless mucus of the soft plasma-body, this true "matter of life," is able to secrete the neatest, most regular, and most complicated structures. This secretive skill is simply a result of *inherited adaptation*, and by it we learn to understand how this same "primæval slime"—this same protoplasm—can produce in the bodies of animals and plants the most different and most complicated cellular forms.

It is, moreover, a matter of special interest that the most ancient organism, the remains of which are found in a petrified condition, belongs to the Polythalamia. This organism is the "Canadian Life's-dawn" (*Eozoon canadense*), which has already been mentioned, and which was found a few years ago in the Ottawa formation (in the deepest strata of the Laurentian system), on the Ottawa river in Canada. If we expected to find organic remains at all in these most ancient deposits of the primordial period, we should certainly look for such of the most simple Protista as are covered with a solid shell, and in the organization of which the difference between animal and plant is as yet not indicated.

We know of but few species of the *Sun-animalcules* (Heliozoa), the second class of the Rhizopoda. One species is very frequently found in our fresh waters. It was observed even in the last century by a clergyman in Dantzic, Eichhorn by name, and it has been called after him, *Actinosphærium*

Eichhornii. To the naked eye it appears as a gelatinous grey globule of mucus, about the size of a pin's head. Looking at it through the microscope, we see hundreds or thousands of fine mucous threads radiating from the central plasma body, and perceive that the inner layer of its cell-substance is different from the outer layer, which forms a bladder-like membrane. In consequence of its structure, this, the little sun-animalcule, although wanting a shell, really rises above the structureless *Acyttaria*, and forms the transition from these to the *Radiolaria*. The genus *Cystophrys* is of a nature akin to it.

The *Basket-shells* (*Radiolaria*) form the third and last class of the *Rhizopoda*. Their lower forms are closely allied to the *Heliozoa* and *Acyttaria*, whereas their higher forms rise far above them. They are essentially distinguished from both by the fact that the central part of their body is composed of many cells, and surrounded by a solid membrane. This closed "central capsule," generally of a globular shape, is covered by a mucous layer of plasma, out of which there radiate on all sides thousands of exceedingly fine threads, the branching and confluent so-called pseudopodia. Between these are scattered numerous yellow cells of unknown function, containing grains of starch. Most *Radiolaria* are characterized by a highly developed skeleton, which consists of flint, and displays a wonderful richness of the neatest and most curious forms. Sometimes this flinty skeleton forms a simple trellice-work ball (Fig. 16 s), sometimes a marvellous system of several concentric trelliced balls, encased in one another, and connected by radial staves. In most cases delicate spikes, which are frequently branched like a tree, radiate from the surface of the balls. In other

cases the whole skeleton consists of only one flinty star, and is then generally composed of twenty staves, distributed according to definite mathematical laws, and united in a

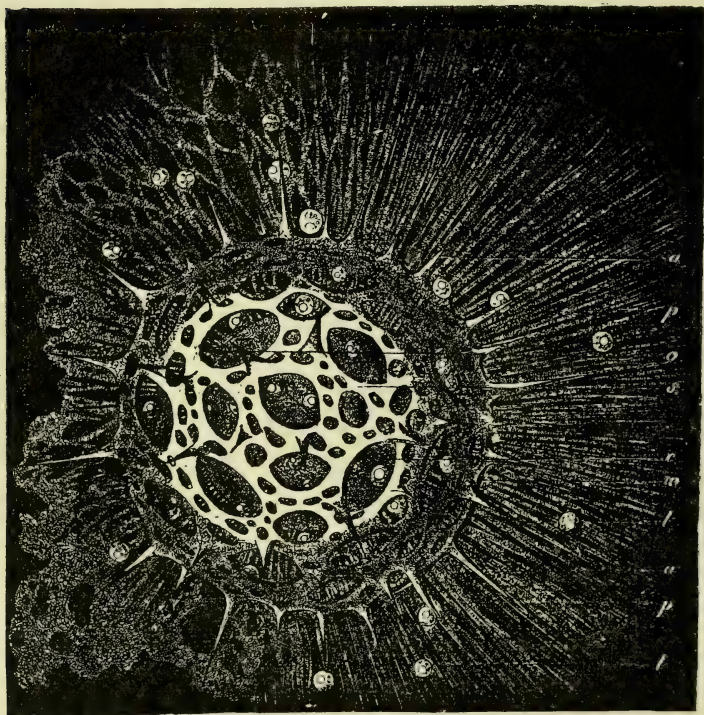


FIG. 16.—*Cyrtidosphæra echinoides*, 400 times enlarged. *c*. Globular central capsule. *s*. Basket-work of the perforated flinty shell. *a*. Radial spikes, which radiate from the latter. *p*. The pseudo-feet radiating from the mucons covering surrounding the central capsule. *l*. Yellow globular cells, scattered between the latter, containing grains of starch.

common central point. The skeletons of other Radiolaria again form symmetrical many-chambered structures, as in the case of the Polythalamia. Perhaps no other group of

organisms develop in the formation of their skeletons such an amount of various fundamental forms, such geometrical regularity, and such elegant architecture. Most of the forms as yet discovered, I have given in the atlas accompanying my Monograph of the Radiolaria.²³ Here I shall only give as an example the picture of one of the simplest forms, the *Cyrtidosphæra echinoides* of Nice. The skeleton in this case consists only of a simple trelliced ball (*s*), with short radial spikes (*a*), which loosely surround the central capsule (*c*). Out of the mucous covering, enclosing the latter, radiate a great number of delicate little pseudopodia (*p*), which are partly drawn back underneath the shell, and fused into a lumpy mass of mucus. Between these are scattered a number of yellow cells (*l*).

Most Acyttaria live only at the bottom of the sea, on stones and seaweeds, or creep about in sand and mud by means of their pseudopodia, but most Radiolaria swim on the surface of the sea by means of long pseudopodia extending in all directions. They live together there in immense numbers, but are mostly so small that they have been almost completely overlooked, and have only become accurately known during the last fourteen years. Certain Radiolaria living in communities (Polycyttaria) form gelatinous lumps of some lines in diameter. On the other hand, most of those living isolated (Monocyttaria) are invisible to the naked eye; but still their petrified shells are found accumulated in such masses that in many places they form entire mountains; for example, the Nicobar Islands in the Indian Archipelago, and the Island of Barbadoes in the Antilles.

As most readers are probably but little acquainted with the eight classes of the Protista just mentioned, I shall

now add some further general observations on their natural history. The great majority of all Protista live in the sea, some swimming freely on the surface, some creeping at the bottom, and others attached to stones, shells, plants, etc. Many species of Protista also live in fresh water, but only a very small number on dry land (for example, Myxomycetes and some Protoplasta). Most of them can be seen only through the microscope, except when millions of individuals are found accumulated. Only a few of them attain a diameter of some lines, or as much as an inch. What they lack in size of body they make up for by producing astonishing numbers of individuals, and they very considerably influence in this way the economy of nature. The imperishable remains of dead Protista, for instance, the flinty shells of the Diatomeæ and Radiolaria, and the calcareous shells of the Acyttaria, often form large rock masses.

In regard to their *vital phenomena*, especially those of nutrition and propagation, some Protista are more allied to plants, others more to animals. Both in their mode of taking food and in the chemical changes of their living substance, they sometimes more resemble the lower animals, at others the lower plants. *Free locomotion* is possessed by many Protista, while others are without it; but this does not constitute a characteristic distinction, as we know of undoubted animals which entirely lack free locomotion, and of genuine plants which possess it. All Protista have a *soul*—that is to say, are “animate”—as well as all animals and all plants. The soul’s activity in the Protista manifests itself in their *irritability*, that is, in the movements and other changes which take place in consequence of mechan-

ical, electrical, and chemical irritation of their contractile protoplasm. Consciousness and the capability of will and thought are probably wanting in all Protista. However, the same qualities are in the same degree also wanting in many of the lower animals, whereas many of the higher animals in these respects are scarcely inferior to the lower races of human beings. In the Protista, as in all other organisms, the activities of the soul are traceable to molecular motions in the protoplasm.

The most important *physiological characteristic* of the kingdom Protista lies in the exclusively *non-sexual propagation* of all the organisms belonging to it. The higher animals and plants multiply almost exclusively in a sexual manner. The lower animals and plants multiply also, in many cases, in a non-sexual manner, by division, the formation of buds, the formation of germs, etc. But sexual propagation almost always exists by the side of it, and often regularly alternates with it in succeeding generations (Meta-genesis, vol. i. p. 206). All Protista, on the other hand, propagate themselves exclusively in a non-sexual manner, and in fact, the distinction of the two sexes among them has not been effected—there are neither male nor female Protista.

The Protista in regard to their vital phenomena stand midway between animals and plants, that is to say, between their lowest forms; and the same must be said in regard to the *chemical composition* of their bodies. One of the most important distinctions between the chemical composition of animal and vegetable bodies consists in the characteristic formation of the skeleton. The skeleton, or the solid scaffolding of the body in most genuine plants, consists of a substance called cellulose, devoid of nitrogen, but secreted by the

nitrogenous cell-substance, or protoplasm. In most genuine animals, on the other hand, the skeleton generally consists either of nitrogenous combinations (chitin, etc.) or of calcareous earth. In this respect some Protista are more like plants, others more like animals. In many of them the skeleton is principally or entirely formed of calcareous earth, which is met with both in animal and vegetable bodies. But the active vital substance in all cases is the mucous protoplasm.

In regard to the *form* of the Protista, it is to be remarked that the *individuality* of their body almost always remains at an extremely low stage of development. Very many Protista remain for life simple plastids or individuals of the first order. Others, indeed, form colonies or republics of plastids by the union of several individuals. But even these higher individuals of the second order, formed by the combination of simple plastids, for the most part remain at a very low stage of development. The members of such communities among the Protista remain very similar one to another, and never, or only in a slight degree, commence a division of labour, and are consequently as little able to render their community fit for higher functions as are, for example, the savages of Australia. The community of the plastids remains in most cases very loose, and each single plastid retains in a great measure its own individual independence.

A second structural characteristic, which next to their low stage of individuality especially distinguishes the Protista, is the low stage of development of their stereometrical fundamental forms. As I have shown in my theory of fundamental forms (in the fourth book of the General Morphology), a definite geometrical fundamental form can

be pointed out in most organisms, both in the general form of the body and in the form of the individual parts. This ideal fundamental form, or type, which is determined by the number, position, combination, and differentiation of the component parts, stands in just the same relation to the *real* organic form as the ideal geometrical fundamental form of crystals does to their imperfect *real* form. In most bodies and parts of the bodies of animals and plants this fundamental form is a pyramid. It is a regular pyramid in the so-called "regular radiate" forms, and an irregular pyramid in the more highly differentiated, so-called "bilaterally symmetrical" forms. (Compare the plates in the first volume of my General Morphology, pp. 556-558.) Among the Protista this pyramidal type, which prevails in the animal and vegetable kingdom, is on the whole rare, and instead of it we have either quite irregular (amorphous) or more simple, regular geometrical types; especially frequent are the sphere, the cylinder, the ellipsoid, the spheroid, the double cone, the cone, the regular polygon (tetrahedron, hexahedron, octahedron, dodecahedron, icosahedron), etc. All the fundamental forms of the pro-morphological system, which are of a low rank in that system, prevail in the Protista. However, in many Protista there occur also the higher, regular, and bilateral types, fundamental forms which predominate in the animal and vegetable kingdoms. In this respect some of the Protista are frequently more closely allied to animals (as the Acyrtaria), others more so to plants (as the Radiolaria).

With regard to the *palæontological development of the kingdom Protista*, we may form various, but necessarily very unsafe, genealogical hypotheses. Perhaps the individual classes of the kingdom are independent tribes, or phyla,

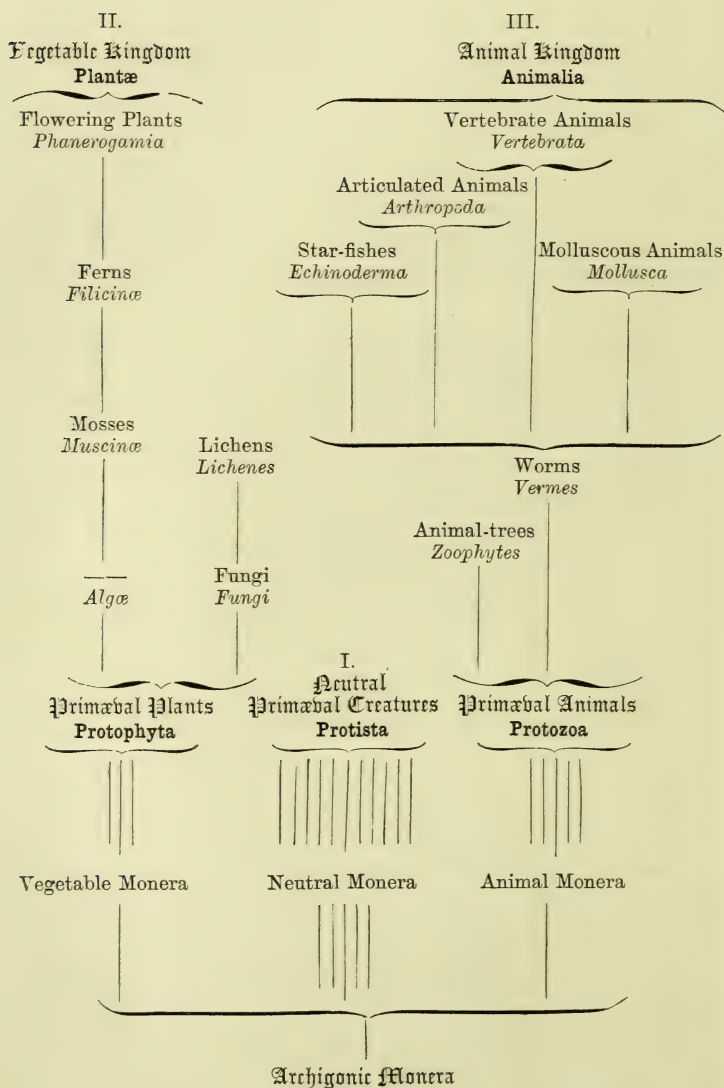
which have developed independently of one another and independently of the animal and the vegetable kingdoms. Even if we adopt the monophyletic hypothesis of descent, and maintain a common origin from a single form of Moneron for all organisms, without exception, which ever have lived and still live upon the earth, even in this case the connection of the neutral Protista on the one hand with the vegetable kingdom, and on the other hand with the animal kingdom, must be considered as very vague. We must regard them (compare p. 74) as lower offshoots which have developed directly out of the root of the great double-branched organic pedigree, or perhaps out of the lowest tribe of Protista, which may be supposed to have shot up midway between the two diverging high and vigorous trunks of the animal and vegetable kingdoms. The individual classes of the Protista, whether they are more closely connected at their roots in groups, or only form a loose bunch of root off-sets, must in this case be regarded as having nothing to do either with the diverging groups of organisms belonging to the animal kingdom on the right, or to the vegetable kingdom on the left. They must be supposed to have retained the original simple character of the common primæval living thing more than have genuine animals and genuine plants.

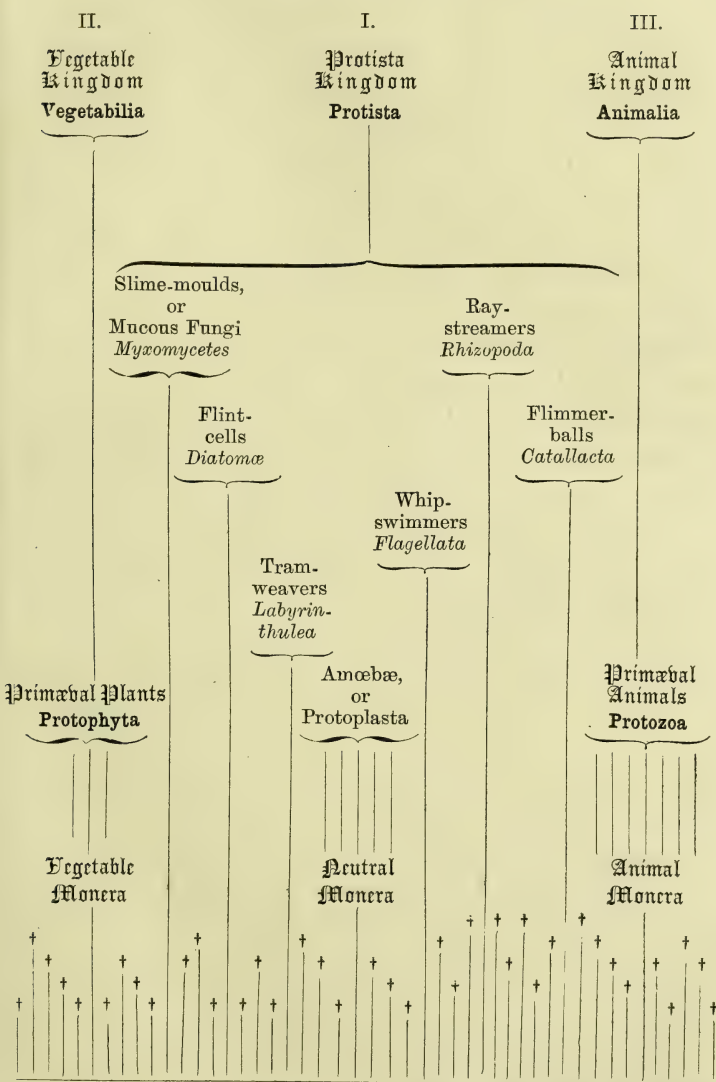
. But if we adopt the polyphyletic hypothesis of descent, we have to imagine a number of organic tribes, or phyla, which all shoot up by spontaneous generation out of the same ground, by the side of and independent of one another. (Compare p. 75.) In that case numbers of different Monera must have arisen by spontaneous generation whose differences would depend only upon slight, to us imperceptible, differences in their chemical composition, and

consequently upon differences in their capability of development. A small number of Monera would then have given origin to the animal kingdom, and, again, a small number would have produced the vegetable kingdom. Between these two groups, however, there would have developed, independently of them, a large number of independent tribes, which have remained at a lower stage of organization, and which have neither developed into genuine plants nor into genuine animals.

A safe means of deciding between the monophyletic and polyphyletic hypotheses is as yet quite impossible, considering the imperfect state of our phylogenetic knowledge. The different groups of Protista, and those lowest forms of the animal kingdom and of the vegetable kingdom which are scarcely distinguishable from the Protista, show such a close connection with one another and such a confused mixture of characteristics, that at present any systematic division and arrangement of the groups of forms seem more or less artificial and forced. Hence the attempt here offered must be regarded as entirely provisional. But the more deeply we penetrate into the genealogical secrets of this obscure domain of inquiry, the more probable appears the idea that the vegetable kingdom and the animal kingdom are each of independent origin, and that midway between these two great pedigrees a number of other independent small groups of organisms have arisen by repeated acts of spontaneous generation, which on account of their indifferent neutral character, and in consequence of their mixture of animal and vegetable properties, may lay claim to the designation of independent Protista.

Thus, if we assume one entirely independent trunk for





N.B.—The Lines marked with a † indicate extinct tribes of Protista, which have arisen independently by repeated acts of Spontaneous Generation.

the vegetable kingdom, and a second for the animal kingdom, we may set up a number of independent stems of Protista, each of which has developed, quite independently of other stems and trunks, from a special archigonic form of Monera. In order to make this relation more clear, we may imagine the whole world of organisms as an immense meadow which is partially withered, and upon which two many-branched and mighty trees are standing, likewise partially withered. The two great trees represent the animal and vegetable kingdoms, their fresh and still green branches the living animals and plants; the dead branches with withered leaves represent the extinct groups. The withered grass of the meadow corresponds to the numerous extinct tribes, and the few stalks, still green, to the still living phyla of the kingdom Protista. But the common soil of the meadow, from which all have sprung up, is primæval by protoplasm.

CHAPTER XVII.

PEDIGREE AND HISTORY OF THE VEGETABLE KINGDOM.

The Natural System of the Vegetable Kingdom.—Division of the Vegetable Kingdom into Six Branches and Eighteen Classes.—The Flowerless Plants (Cryptogamia).—Sub-kingdom of the Thallus Plants.—The Tangles, or Algæ (Primary Algæ, Green Algæ, Brown Algæ, Red Algæ).—The Thread-plants, or Inophytes (Lichens and Fungi).—Sub-kingdom of the Prothallus Plants.—The Mosses, or Muscinæ (Water-mosses, Liverworts, Leaf-mosses, Bog-mosses).—The Ferns, or Filicinæ (Leaf-ferns, Bamboo-ferns, Water-ferns, Scale-ferns).—Sub-kingdom of Flowering Plants (Phanerogamia).—The Gymnosperms, or Plants with Naked Seeds (Palm-ferns = Cycadeæ; Pines = Coniferæ).—The Angiosperms, or Plants with Enclosed Seeds.—Monocotylæ.—Dicotylæ.—Cup-blossoms (Apetalæ).—Star-blossoms (Diapetalæ).—Bell-blossoms (Gamopetalæ).

EVERY attempt that we make to gain a knowledge of the pedigree of any small or large group of organisms related by blood must, in the first instance, start with the evidence afforded by the existing "*natural system*" of this group. For although the natural system of animals and plants will never become finally settled, but will always represent a merely approximate knowledge of true blood relationship, still it will always possess great importance as a hypothetical pedigree. It is true, by a "*natural system*" most zoologists and botanists only endeavour to express in a concise way the subjective conceptions which

each has formed of the objective "*form-relationships*" of organisms. These form-relationships, however, as the reader has seen, are in reality the necessary result of true *blood relationship*. Consequently, every morphologist in promoting our knowledge of the natural system, at the same time promotes our knowledge of the pedigree, whether he wishes it or not. The more the natural system deserves its name, and the more firmly it is established upon the concordance of results obtained from the study of comparative anatomy, ontogeny, and palæontology, the more surely may we consider it as the approximate expression of the true pedigree of the organic world.

In entering upon the task contemplated in this chapter, the genealogy of the vegetable kingdom, we shall have, according to this principle, first to glance at the *natural system of the vegetable kingdom* as it is at present (with more or less important modifications) adopted by most botanists. According to the system generally in vogue, the whole series of vegetable forms is divided into two main groups. These main divisions, or sub-kingdoms, are the same as were distinguished more than a century ago by Charles Linnæus, the founder of systematic natural history, and which he called *Cryptogamia*, or secretly-blossoming plants, and *Phanerogamia*, or openly-flowering plants. The latter, Linnæus, in his artificial system of plants, divided, according to the different number, formation, and combination of the anthers, and also according to the distribution of the sexual organs, into twenty-three different classes, and then added the *Cryptogamia* to these as the twenty-fourth and last class.

The *Cryptogamia*, the secretly-blossoming or flowerless

plants, which were formerly but little observed, have in consequence of the careful investigations of recent times been proved to present such a great variety of forms, and such a marked difference in their coarser and finer structure, that we must distinguish no less than fourteen different classes of them; whereas the number of classes of flowering plants, or *Phanerogamia*, may be limited to four. However, these *eighteen classes of the vegetable kingdom* can again be naturally grouped in such a manner that we are able to distinguish in all *six main divisions or branches* of the vegetable kingdom. Two of these six branches belong to the flowering, and four to the flowerless plants. The table on page 82 shows how the eighteen classes are distributed among the six branches, and how these again fall under the *sub-kingdoms* of the vegetable kingdom.

The one sub-kingdom of the *Cryptogamia* may now be naturally divided into *two* divisions, or sub-kingdoms, differing very essentially in their internal structure and in their external form, namely, the *Thallus* plants and the *Prothallus* plants. The group of *Thallus plants* comprises the two large branches of Tangles, or Algæ, which live in water, and the Thread-plants, or Inophytes (Lichens and Fungi), which grow on land, upon stones, bark of trees, upon decaying bodies, etc. The group of *Prothallus plants*, on the other hand, comprises the two branches of Mosses and Ferns, containing a great variety of forms.

All *Thallus plants*, or *Thallophytes*, can be directly recognized from the fact that the two morphological fundamental organs of all other plants, stem and leaves, cannot be distinguished in their structure. The complete body of all Algæ and of all Thread-plants is a mass composed of simple

cells, which is called a *lobe*, or *thallus*. This thallus is as yet not differentiated into axial-organs (stem and root) and leaf-organs. On this account, as well as through many other peculiarities, the Thallophytes contrast strongly with all remaining plants—those comprised under the two sub-kingdoms of Prothallus plants and Flowering plants—and for this reason the two latter sub-kingdoms are frequently classed together under the name of *Stemmed plants*, or *Cormophytes*. The following table will explain the relation of these three sub-kingdoms to one another according to the two different views :—

I. Flowerless Plants. (<i>Cryptogamia</i>)	{ A. Thallus Plants (<i>Thallophyta</i>) B. Prothallus Plants (<i>Prothallophyta</i>)	I. Thallus Plants (<i>Thallophyta</i>)
		II. Stemmed Plants (<i>Cormophyta</i>)
II. Flowering Plants (<i>Phanerogamia</i>)	{ C. Flowering Plants (<i>Phanerogamia</i>)	

The stemmed plants, or Cormophytes, in the organization of which the difference of axial-organs (stem and root) and leaf-organs is already developed, form at present, and have, indeed, for a very long period formed, the principal portion of the vegetable world. However, this was not always the case. In fact, stemmed plants, not only of the flowering group, but even of the prothallus group, did not exist at all during that immeasurably long space of time which forms the beginning of the first great division of the organic history of the earth, under the name of the archilithic, or primordial period. The reader will recollect that during this period the Laurentian, Cambrian, and Silurian systems of strata were deposited, the thickness of which, taken as a whole,

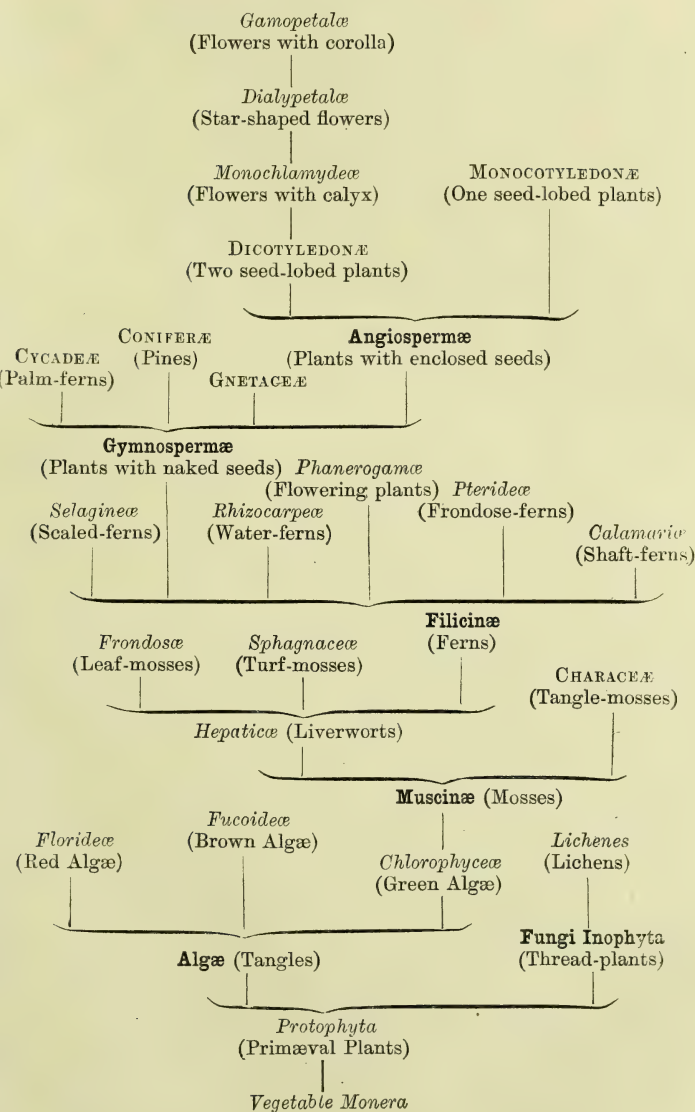
amounts to about 70,000 feet. Now, as the thickness of all the more recent superincumbent strata, from the Devonian to the deposits of the present time, taken together, amounts to only about 60,000 feet, we were enabled from this fact alone to draw the conclusion—which is probable also for other reasons—that the archilithic, or primordial, period was of longer duration than the whole succeeding period down to the present time. During the whole of this immeasurable space of time, which probably comprises many millions of centuries, vegetable life on our earth seems to have been represented exclusively by the sub-kingdom of Thallus plants, and, moreover, only by the class of marine Thallus plants, that is to say, the Algæ. At least all the petrified remains which are positively known to be of the primordial period belong exclusively to this class. As all the animal remains of this immense period also belong exclusively to animals that lived in water, we come to the conclusion that at that time organisms adapted to a life on land did not exist at all.

For these reasons the first and most imperfect of the great provinces or branches of the vegetable kingdom, the division of the Algæ, or Tangles, must be of special interest to us. But, in addition, there is the interest which this group offers when viewed by itself. In spite of the exceedingly simple composition of their constituent cells, which are but little differentiated, the Algæ show an extraordinary variety of different forms. To them belong the simplest and most imperfect of all forms, as well as very highly developed and peculiar forms. The different groups of Algæ are distinguished as much by size of body as by the perfection and variety of their outer form. At the lowest stage we find

SYSTEMATIC VIEW

Of the Six Branches and Eighteen Classes of the Vegetable Kingdom.

<i>Primary Groups or Sub-Kingdoms of the Vegetable Kingdom.</i>	<i>Branches or Clades of the Vegetable Kingdom.</i>	<i>Classes of the Vegetable Kingdom.</i>	<i>Systematic Name of the Classes.</i>
A. Thallus Plants Thallophyta	I. Algæ Tangles	1. Primæval algæ	1. <i>Archephyceæ</i> (Protophyta)
		2. Green algæ	2. <i>Chlorophyceæ</i> (Chloroalgæ)
		3. Brown algæ	3. <i>Phæophyceæ</i> (Fucoideæ)
		4. Red algæ	4. <i>Rhodophyceæ</i> (Florideæ)
	II. Thread-plants Inophyta	5. Lichens	5. <i>Lichenes</i>
		6. Fungi	6. <i>Fungi</i>
B. Prothallus Plants Prothallophyta	III. Mosses Muscineæ	7. Tangle-mosses	7. <i>Charobrya</i> (Characeæ)
		8. Liverworts	8. <i>Thallobrya</i> (Hepaticæ)
		9. Frondose- mosses	9. <i>Phyllobrya</i> (Frondosæ)
		10. Turf-mosses	10. <i>Sphagnobrya</i> (Sphagnaceæ)
	IV. Ferns Felicinæ	11. Shaft-ferns	11. <i>Calamariæ</i> (Calamophyta)
		12. Frondose- ferns	12. <i>Filices</i> (Pterideæ)
C. Flowering Plants Phanerogamia	V. Plants with Naked Seeds <i>Gymnosperma</i>	13. Aquatic ferns	13. <i>Rhizocarpeæ</i> (Hydropterides)
		14. Scale-ferns	14. <i>Selaginææ</i> (Lepidophyta)
	VI. Plants with Enclosed Seeds <i>Angiosperma</i>	15. Palm-ferns	15. <i>Cycadeæ</i>
		16. Pines	16. <i>Coniferæ</i>
		17. Plants with one seed lobe	17. <i>Monocotylæ</i>
		18. Plants with two seed lobes	18. <i>Dicotylæ</i>



such species as the minute *Protococcus*, several hundred thousands of which occupy a space no larger than a pin's head. At the highest stage we marvel at the gigantic *Macrocyts*, which attain a length of from 300 to 400 feet, the longest of all forms in the vegetable kingdom. It is possible that a large portion of the coal has been formed out of *Algæ*. If not for these reasons, yet the *Algæ* must excite our special attention from the fact that they form the beginning of vegetable life, and contain the original forms of all other groups of plants, supposing that our monophyletic hypothesis of a common origin for all groups of plants is correct. (Compare p. 83.)

Most people living inland can form but a very imperfect idea of this exceedingly interesting branch of the vegetable kingdom, because they know only its proportionately small and simple representatives living in fresh water. The slimy green aquatic filaments and flakes of our pools and ditches and springs, the light green slimy coverings of all kinds of wood which have for any length of time been in contact with water, the yellowish green, frothy, and oozy growths of our village ponds, the green filaments resembling tufts of hair which occur everywhere in fresh water, stagnant and flowing, are for the most part composed of different species of *Algæ*. Only those who have visited the sea-shore, and wondered at the immense masses of cast-up seaweed, and who, from the rocky coast of the Mediterranean, have seen through the clear blue waters the beautifully-formed and highly-coloured vegetation of *Algæ* at the bottom, know how to estimate the importance of the class of *Algæ*. And yet, even these marine *Algæ*-forests of European shores, so rich in forms, give only a faint idea

of the colossal forests of Sargasso in the Atlantic ocean, those immense banks of Algæ, covering a space of about 40,000 square miles—the same which made Columbus, on his voyage of discovery, believe that a continent was near. Similar but far more extensive forests of Algæ grew in the primæval ocean, probably in dense masses, and what countless generations of these archilithic Algæ have died out one after another is attested, among other facts, by the vast thickness of Silurian alum schists in Sweden, the peculiar composition of which proceeds from those masses of submarine Algæ. According to the recently expressed opinion of Frederick Mohr, a geologist of Bonn, even the greater part of our coal seams have arisen out of the accumulated dead bodies of the Algæ forests of the ocean.

Within the branch of the Algæ we distinguish four different classes, each of which is again divided into several orders and families. These again contain a large number of different genera and species. We designate these four classes as Primæval Algæ, or Archephyceæ, Green Algæ, or Chlorophyceæ, Brown Algæ, or Phæophyceæ, and Red Algæ, or Rhodophyceæ.

The first class of Algæ, the *Primæval* Algæ (Archephyceæ), might also be called *primæval plants*, because they contain the simplest and most imperfect of all plants, and, among them, those most ancient of all vegetable organisms out of which all other plants have originated. To them therefore belong those most ancient of all vegetable Monera which arose by spontaneous generation in the beginning of the Laurentian period. Further, we have to reckon among them all those vegetable forms of the simplest organization which first developed out of the Monera in the Laurentian period,

and which possessed the form of a single plastid. At first the entire body of one of these small primary plants consisted only of a most simple cytod (a plastid without kernel), and afterwards attained the higher form of a simple cell, by the separation of a kernel in the plasma. (Compare above, vol. i. p. 345.) Even at the present day there exist various most simple forms of Algæ which have deviated but little from the original primary plants. Among them are the Algæ of the families Codiolaceæ, Protococcaceæ, Desmidiaceæ, Palmellaceæ, Hydrodictyeæ, and several others. The remarkable group of Phycobryaceæ (Chroococcaceæ and Oscillariaceæ) might also be comprised among them, unless we prefer to consider them as an independent tribe of the kingdom Protista.

The monoplasic Protophyta—that is, those primary Algæ formed by a single plastid—are of the greatest interest, because the vegetable organism in this case completes its whole course of life as a perfectly simple “individual of the first order,” either as a cytod without kernel, or as a cell containing a kernel.

Among the primary plants consisting of a single cytod are the exceedingly remarkable Siphonæ, which are of considerable size, and strangely “mimic” the forms of higher plants. Many of the Siphonæ attain a size of several feet, and resemble an elegant moss (*Bryopsis*), or in some cases a perfect flowering plant with stalks, roots, and leaves (*Caulerpa*) (Fig. 17). Yet the whole of this large body, externally so variously differentiated, consists internally of an entirely simple sack, possessing the negative characters of a simple cytod.

These curious Siphonæ, *Vaucheriæ*, and *Caulerpæ* show



FIG. 17.—*Caulerpa denticulata*, a monoplastic Siphonean of the natural size. The entire branching primary plant, which appears to consist of a creeping stalk with fibrous roots and indented leaves, is in reality only a single plastid, and moreover a cytod (without a kernel), not even attaining the grade of a cell with nucleus.

us to how great a degree of elaboration a single cytod, although a most simple individual of the first order, can develop by continuous adaptation to the relations of the outer world. Even the *single-celled primary plants*—which are distinguished from the monocytons by possessing a kernel—develop into a great variety of exquisite forms by adaptation; this is the case especially with the beautiful

Desmidiaceæ, of which a species of *Euastrum* is represented in Fig. 18 as a specimen.

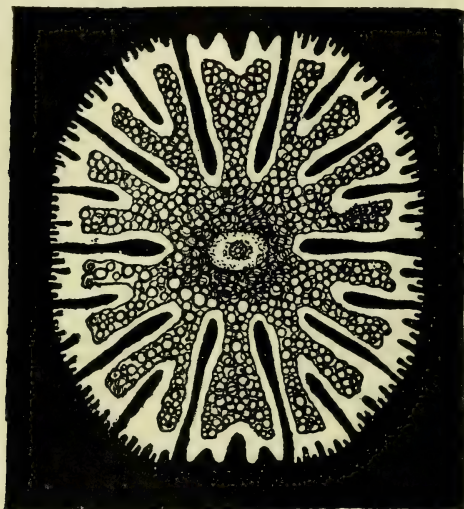


FIG. 18.—*Euastrum rota*, a single-celled Desmid, much enlarged. The whole of the star-shaped body of this primæval plant has the formal value of a simple cell. In its centre lies the kernel, and within this the kernel corpuscle, or speck.

It is very probable that similar primæval plants, the soft body of which, however, was not capable of being preserved in a fossil state, at one time peopled the Laurentian primæval sea in great masses and varieties, and in a great abundance of forms, without, however, going beyond the stage of individuality of a simple plastid.

The group of *Green Tangles* (*Chlorophyceæ*), or *Green Algæ* (*Chloroalgæ*), are the second class, and the most closely allied to the primæval group. Like the majority of the *Archephyceæ*, all the *Chlorophyceæ* are coloured green, and

by the same colouring matter—the substance called leaf-green, or chlorophyll—which colours the leaves of all the higher plants.

To this class belong, besides a great number of low marine Algæ, most of the Algæ of fresh water, the common water hair-weeds, or Confervæ, the green slime-balls, or Glœosphæræ, the bright green water-lettuce, or *Ulva*, which resembles a very thin and long lettuce leaf, and also numerous small microscopic algæ, dense masses of which form a light green shiny covering to all sorts of objects lying in water—wood, stones, etc.

These forms, however, rise above the simple primary Algæ in the composition and differentiation of their body. As the green Algæ, like the primæval Algæ, mostly possess a very soft body, they are but rarely capable of being petrified. However, it can scarcely be doubted that this class of Algæ—which was the first to develop out of the preceding one—most extensively and variously peopled the fresh and salt waters of the earth in early times.

In the third class, that of the *Brown Tangles* (Phæo-phyceæ), or *Black Algæ* (Fucoideæ), the *branch* of the Algæ attains its highest stage of development, at least in regard to size and body. The characteristic colour of the Fucoid is more or less dark brown, sometimes tending more to an olive green or yellowish green, sometimes more to a brownish red or black colour.

Among these are the largest of all Algæ, which are at the same time the longest of all plants, namely, the colossal giant Algæ, amongst which the *Macrocystis pyrifera*, on the coast of California, attains a length of 400 feet. Also, among our indigenous Algæ, the largest

forms belong to this group. Especially I may mention here the stately sugar-tangle (*Laminaria*), whose slimy, olive green thallus-body, resembling gigantic leaves of from 10 to 15 feet in length, and from a half to one foot in breadth, are thrown up in great masses on the coasts of the North and Baltic seas.

To this class belongs also the bladder-wrack (*Fucus vesiculosus*) common in our seas, whose fork-shaped, deeply-cut leaves are kept floating on the water by numerous air bladders (as is the case, too, with many other brown Algæ). The freely floating Sargasso Alga (*Sargasso bacciferum*), which forms the meadows or forests of the Sargasso Sea, also belongs to this class.

Although each individual of these large alga-trees is composed of many millions of cells, yet at the beginning of its existence it consists, like all higher plants, of a single cell—a simple egg. This egg—for example, in the case of our common bladder-wrack—is a naked, uncovered cell, and as such is so like the naked egg-cells of lower marine animals—for example, those of the Medusæ—that they might easily be mistaken one for another (Fig. 19).

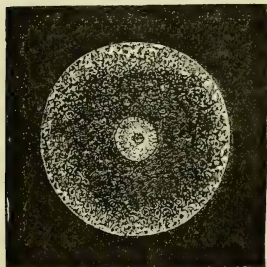


FIG. 19.—The egg of the common bladder-wrack (*Fucus vesiculosus*), a simple naked cell, much enlarged. In the centre of the naked globule of protoplasm the bright kernel is visible.

It was probably the Fucoideæ, or Brown Algæ, which during the primordial period, to a great extent, constituted the characteristic alga-forests of that immense space of time. Their petrified remains, especially those of

the Silurian period, which have been preserved, can, it is true, give us but a faint idea of them, because the material of these Algæ, like that of most others, is ill-suited for preservation in a fossil state. As has already been remarked, a large portion of coal is perhaps composed of them.

Less important is the fourth class of Algæ, that of the *Rose-coloured Algæ* (Rhodophycæ), or *Red Sea-weeds* (Florideæ). This class, it is true, presents a great number of different forms; but most of them are of much smaller size than the Brown Algæ. Although they are inferior to the latter in perfection and differentiation, they far surpass them in some other respects. To them belong the most beautiful and elegant of all Algæ, which on account of the fine plumose division of their leaf-like bodies, and also on account of their pure and delicate red colour, are among the most charming of plants. The characteristic red colour sometimes appears as a deep purple, sometimes as a glowing scarlet, sometimes as a delicate rose tint, and may verge into violet and bluish purple, or on the other hand into brown and green tints of marvellous splendour. Whoever has visited one of our sea-coast watering places, must have admired the lovely forms of the Florideæ, which are frequently dried on white paper and offered for sale.

Most of the Red Algæ are so delicate, that they are quite incapable of being petrified; this is the case with the splendid Ptilotes, Plocamia, Delesseria, etc. However, there are individual forms, like the Chondria and Sphærococca, which possess a harder thallus, often almost as hard as cartilage, and of these fossil remains have been preserved—principally in the Silurian, Devonian, and Carboniferous strata, and later in the oolites. It is probable that this class also had

an important share in the composition of the archilithic Algæ flora.

If we now again take into consideration the flora of the primordial period, which was exclusively formed by the group of Algæ, we can see that it is not improbable that its four subordinate classes had a share in the composition of those submarine forests of the primæval oceans, similar to that which the four types of vegetation—trees with trunks, flowering shrubs, grass, and tender leaf-ferns and mosses—at present take in the composition of our recent land forests.

We may suppose that the submarine tree forests of the primordial period were formed by the huge Brown Algæ, or Fucoideæ. The many-coloured flowers at the foot of these gigantic trees were represented by the gay Red Algæ, or Florideæ. The green grass between was formed by the hair-like bunches of Green Algæ, or Chloroalgæ. Finally, the tender foliage of ferns and mosses, which at present cover the ground of our forests, fill the crevices left by other plants, and even settle on the trunks of the trees, at that time probably had representatives in the moss and fern-like Siphonææ, in the Caulerpa and Bryopsis, from among the class of the primary Algæ, Protophyta, or Archephyceæ.

With regard to the relationships of the different classes of Algæ to one another and to other plants, it is exceedingly probable that the Primary Algæ, or Archephyceæ, as already remarked, form the common root of the pedigree, not merely for the different classes of Algæ, but for the whole vegetable kingdom. On this account they may with justice be designated as primæval plants, or Protophyta.

Out of the naked vegetable Monera, in the beginning of the

Laurentian period, enclosed cytods were probably the first to arise (vol. i. p. 345), by the naked, structureless, albuminous substance of the Monera becoming condensed in the form of a pellicle on the surface, or by secreting a membrane. At a later period, out of these enclosed cytods genuine vegetable cells probably arose, as a kernel or nucleus separated itself in the interior from the surrounding cell-substance or plasma.

The three classes of Green Algæ, Brown Algæ, and Red Algæ, are perhaps three distinct classes, which have arisen independently of one another out of the common radical group of Primæval Algæ, and then developed themselves further (each according to its kind), and have variously branched off into orders and families. The Brown and Red Algæ possess no close blood relationship to the other classes of the vegetable kingdom. These latter have most probably arisen out of the Primæval Algæ, either directly or by the intermediate step of the Green Algæ.

It is probable that Mosses (out of which, at a later time, Ferns developed) proceeded from a group of Green Algæ, and that Fungi and Lichens proceeded from a group of Primæval Algæ. The Phanerogamia developed at a much later period out of Ferns.

As a second class of the Vegetable Kingdom we have above mentioned the *Thread-plants* (Inophyta). We understood by this term the two closely related classes of *Lichens* and *Fungi*. It is possible that these Thallus plants have not arisen out of the Primæval Algæ, but out of one or more Monera, which, independently of the latter, arose by spontaneous generation. It appears conceivable that many of the lowest Fungi, as for example, many ferment-causing

fungi (forms of *Micrococcus*, etc.), owe their origin to a number of different *archigonic* Monera (that is, Monera originating by spontaneous generation).

In any case the Thread-plants cannot be considered as the progenitors of any of the higher vegetable classes. Lichens, as well as fungi, are distinct from the higher plants in the composition of their soft bodies, consisting as it does of a dense felt-work of very long, variously interwoven, and peculiar threads or chains of cells—the so-called *hyphæ*, on which account we distinguish them as a province under the name Thread-plants. From their peculiar nature they could not leave any important fossil remains, and consequently we can form only a very vague guess at their palæontological development.

The first class of Thread-plants, the *Fungi*, exhibit a very close relationship to the lowest Algæ; the Algo-fungi, or Phycomycetes (the Saprolegniæ and Peronosporæ) in reality only differ from the bladder-wracks and Siphonææ (the *Vaucheria* and *Caulerpa*) mentioned previously by the want of leaf-green, or chlorophyll. But, on the other hand, all genuine Fungi have so many peculiarities, and deviate so much from other plants, especially in their mode of taking food, that they might be considered as an entirely distinct province of the vegetable kingdom.

Other plants live mostly upon inorganic food, upon simple combinations which they render more complicated. They produce protoplasm by the combination of water, carbonic acid, and ammonia. They take in carbonic acid and give out oxygen. But the Fungi, like animals, live upon organic food, consisting of complicated combinations of carbon, which they receive from other organisms and

assimilate. They inhale oxygen and give out carbonic acid like animals. They also never form leaf-green, or chlorophyll, which is so characteristic of most other plants. In like manner they never produce starch. Hence many eminent botanists have repeatedly proposed to remove the Fungi completely out of the vegetable kingdom, and to regard them as a special and third kingdom, between that of animals and plants. By this means our kingdom of Protista would be considerably increased. The Fungi in this case would, in the first place, be allied to the so-called "slime moulds," or Myxomycetes (which, however, never form any hyphæ). But as many Fungi propagate in a sexual manner, and as most botanists, according to the prevalent opinion, look upon Fungi as genuine plants, we shall here leave them in the vegetable kingdom, and connect them with lichens, to which they are at all events most nearly related.

The phyletic origin of Fungi will probably long remain obscure. The close relationship already hinted at between the Phycomycetes and Siphonæ (especially between the Saprolegniæ and Vaucheriæ) suggests to us that they are derived from the latter. Fungi would then have to be considered as Algæ, which by adaptation to a parasitical life have become very peculiarly transformed. Many facts, however, support the supposition that the lowest fungi have originated independently from archigonic Monera.

The second class of Inophyta, the *Lichens* (Lichenes), are very remarkable in relation to phylogeny; for the surprising discoveries of late years have taught us that every Lichen is really composed of two distinct plants—of a low form of Alga (Nostochaceæ, Chroococcaceæ), and of a parasitic form of Fungus (Ascomycetes), which lives as a parasite upon

the former, and upon the nutritive substances prepared by it. The green cells, containing chlorophyll (gonidia), which are found in every lichen, belong to the Alga. But the colourless threads (hyphæ) which, densely interwoven, form the principal mass of the body of Lichens, belong to the parasitic Fungus. But in all cases the two forms of plants—Fungus and Alga—which are always considered as members of two quite distinct provinces of the vegetable kingdom, are so firmly united, and so thoroughly interwoven, that nearly every one looks upon a Lichen as a single organism.

Most Lichens form small, more or less formless or irregularly indented, crust-like coverings to stones, bark of trees, etc. Their colour varies through all possible tints, from the purest white to yellow, red, green, brown, and the deepest black.

Many lichens are important in the economy of nature from the fact that they can settle in the driest and most barren localities, especially on naked rocks upon which no other plant can live. The hard black lava, which covers many square miles of ground in volcanic regions, and which for centuries frequently presents the most determined opposition to the life of every kind of vegetation, is always first occupied by Lichens. It is the white or grey Lichens (Stereocaulon) which, in the most desolate and barren fields of lava, always begin to prepare the naked rocky ground for cultivation, and conquer it for subsequent higher vegetation. Their decaying bodies form the first mould in which mosses, ferns, and flowering plants can afterwards take firm root. Hardy Lichens are also less affected by the severity of climate than any other plants. Hence the naked rocks, even in the highest mountains—for the most

part covered by eternal snow, on which no plant could thrive—are encrusted by the dry bodies of Lichens.

Leaving now the Fungi, Lichens, and Algæ, which are comprised under the name of Thallus plants, we enter upon the second sub-kingdom of the vegetable kingdom, that of the *Prothallus plants* (Prothallophyta), which by some botanists are called phyllogonic Cryptogamia (in contradistinction to the Thallus plants, or thallogonic Cryptogamia). This sub-kingdom comprises the two provinces of *Mosses* and *Ferns*.

Here we meet with (except in a few of the lowest forms) the separation of the vegetable body into two different fundamental organs, axial-organs (stem and root) and leaves (or lateral organs). In this the Prothallus plants resemble the Flowering plants, and hence the two groups have recently often been classed together as stemmed plants, or Cormophytes.

But, on the other hand, Mosses and Ferns resemble the Thallus plants, in the absence of the development of flowers and seeds, and even Linnæus classed them with these, as Cryptogamia, in contradistinction to the plants forming seeds; that is, flowering plants (Anthophyta or Phanerogamia).

Under the name of “Prothallus plants” we combine the closely-related Mosses and Ferns, because both exhibit a peculiar and characteristic “alternation of generation” in the course of their individual development. For every species exhibits two different generations, of which the one is usually called the *Prothallium*, or *Fore-growth*, the other is spoken of as the *Cormus*, or actual *Stem* of the moss or fern.

The first and original generation, the Fore-growth, or Pro-

thallus, also called Protonema, still remains in that lower stage of elaboration manifested throughout life by all Thallus plants; that is to say, stem and leaf-organs have as yet not differentiated, and the entire cell-mass of the Fore-growth corresponds to a simple thallus. The second and more perfect generation of mosses and ferns—the Stem, or Cormus—develops a much more highly elaborate body, which has differentiated into stalk and leaf (as in the case of flowering plants), except in the lowest mosses, where this generation also remains in the lower stage of the thallus.

With the exception of these latter forms the first generation of Mosses and Ferns (the thallus-shaped Fore-growth) always produces a second generation with stem and leaves; the latter in its turn produces the thallus of the first generation, and so on. Thus, in this case, as in the ordinary cases of alternation of generation in animals, the first generation is like the third, fifth, etc., the second like the fourth, sixth, etc. (Compare vol. i. p. 206.)

Of the two main classes of Prothallus plants, the Mosses in general are at a much lower stage of development than the Ferns, and their lowest forms (especially in an anatomical respect) form the transition from the Thallus plants through the Algæ to Ferns. The genealogical connection of Mosses and Ferns which is indicated by this fact can, however, be inferred only from the case of the most imperfect forms of the two classes; for the more perfect and higher groups of mosses and ferns do not stand in any close relation to one another, and develop in completely opposite directions. In any case Mosses have arisen directly out of Thallus plants, and probably out of Green Algæ.

Ferns, on the other hand, are probably derived from

extinct unknown Mosses, which were very nearly related to the lowest liverworts of the present day. In the history of creation, Ferns are of greater importance than Mosses.

The branch of *Mosses* (Muscinæ, also called Musci, or Bryophyta) contains the lower and more imperfect plants of the group of Prothallophytes, which as yet do not possess vessels. Their bodies are mostly so tender and perishable that they are very ill-suited for being preserved in a recognizable state as fossils. Hence the fossil remains of all classes of Mosses are rare and insignificant. It is probable that Mosses developed in very early times out of the Thallus plants, or, to be more precise, out of the Green Algæ. It is probable that in the primordial period there existed aquatic forms of transition from the latter to Mosses, and in the primary period to those living on land. The Mosses of the present day—out of the gradually differentiating development of which comparative anatomy may draw some inferences as to their genealogy—are divided into two different classes, namely: (1) Liverworts; (2) Leafy Mosses.

The first and oldest class of Mosses, which is directly allied to the Green Algæ, or Confervæ, is formed by the *Liverworts* (Hepaticæ, or Thallobrya). The mosses belonging to them are, for the most part, small and insignificant in form, and are little known. Their lowest forms still possess, in both generations, a simple thallus like the Thallus plants; as for example, the Ricciæ and Marchantiaceæ. But the more highly developed liverworts, the Jungermanniaceæ and those akin to them, gradually commence to differentiate stem and leaf, and their most highly-developed forms are closely allied to leaf-mosses. By this transitional series

the liverworts show their direct derivation from the Thallophytes, and more especially from the Green Algæ.

The Mosses, which are generally the only ones known to the uninitiated—and which, in fact, form the principal portion of the whole branch—belong to the second class, or *Leafy Mosses* (*Musci frondosi*, called *Musci* in a narrow sense, also *Phyllobrya*). Among them are most of those pretty little plants which, united in dense groups, form the bright glossy carpet of moss in our woods, or which, in company with liverworts and lichens, cover the bark of trees. As reservoirs, carefully storing up moisture, they are of the greatest importance in the economy of nature. Wherever man mercilessly cuts down and destroys forests, there, as a consequence, disappear the leafy mosses which covered the bark of the trees, or, protected by their shade, clothed the ground, and filled the spaces between the larger plants. Together with the leafy mosses disappear the useful reservoirs which stored up rain and dew for times of drought. Thus arises a disastrous dryness of the ground, which prevents the growth of any rich vegetation. In the greater part of Southern Europe—in Greece, Italy, Sicily, and Spain—mosses have been destroyed by the inconsiderate extirpation of forests, and the ground has thereby been robbed of its most useful stores of moisture; once flourishing and rich tracts of land have been changed into dry and barren wastes. Unfortunately in Germany, also, this rude barbarism is beginning to prevail more and more. It is probable that the small frondose mosses have played this exceedingly important part in nature for a very long time, possibly from the beginning of the primary period. But as their

tender bodies are as little suited as those of all other mosses for being preserved in a fossil state, palæontology can give us no information about this.

We learn from the science of petrifications much more than we do in the case of Mosses of the importance which the second branch of Prothallus plants—that is, Ferns—have had in the history of the vegetable world. Ferns, or more strictly speaking, the “plants of the fern tribe” (Filicineæ, or Pterideæ, also called Pteridophyta, or Vascular Cryptogams), formed during an extremely long period, namely, during the whole primary or palæolithic period, the principal portion of the vegetable world, so that we may without hesitation call it the *era of Fern Forests*. From the beginning of the Devonian period, in which organisms living on land appeared for the first time, namely, during the deposits of the Devonian, Carboniferous, and Permian strata, plants like Ferns predominated so much over all others, that we are justified in giving this name to that period. In the stratifications just mentioned, but above all, in the immense layers of coal of the Carboniferous or coal period, we find such numerous and occasionally well preserved remains of Ferns, that we can form a tolerable vivid picture of the very peculiar land flora of the palæolithic period. In the year 1855 the total number of the then known palæolithic species of plants amounted to about a thousand, and among these there were no less than 872 Ferns. Among the remaining 128 species were 77 Gymnosperms (pines and palm-ferns), 40 Thallus plants (mostly Algæ), and about 20 not accurately definable Cormophyta (stem-plants).

As already remarked, Ferns probably developed out of the lower liverworts in the beginning of the primary period.

In their organization Ferns rise considerably above Mosses, and in their more highly developed forms even approach the flowering plants. In Mosses, as in Thallus plants, the entire body is composed of almost equi-formal cells, little if at all differentiated; but in the tissues of Ferns we find those peculiarly differentiated strings of cells which are called the vessels of plants, and which are universally met with in flowering plants. Hence Ferns are sometimes united as "vascular Cryptogams" with Phanerogams, and the group so formed is contrasted as that of the "vascular plants" with "cellular plants,"—that is, with "cellular cryptogams" (Mosses and Thallus plants). This very important process in the organization of plants—the formation of vessels—first occurred, therefore, in the Devonian period, consequently in the beginning of the second and smaller half of the organic history of the earth.

The branch of Ferns, or Filicinæ, is divided into five distinct classes: (1) Frondose Ferns, or Pteridæ; (2) Reed Ferns, or Calamaria; (3) Aquatic Ferns, or Rhizocarpeæ; (4) Snakes Tongues, or Ophioglossæ; and (5) Scale Ferns, or Lepidophyta. By far the most important of these five classes, and also the richest in forms, were first the Frondose Ferns, and then the Scale-ferns, which formed the principal portion of the palæolithic forests. The Reed Ferns, on the other hand, had at that time already somewhat diminished in number; and of the Aquatic Ferns, we do not even know with certainty whether they then existed. It is difficult for us to form any idea of the very peculiar character of those gloomy palæolithic fern forests, in which the whole of the gay abundance of flowers of our present flora was entirely wanting, and which were not enlivened

by any birds. Of the flowering plants there then existed only the two lowest classes, the pines and palm ferns, with naked seeds, whose simple and insignificant blossoms scarcely deserve the name of flowers.

The phylogeny of Ferns, and of the Gymnosperms which have developed out of them, has been made especially clear by the excellent investigations which Edward Strasburger published in 1872, on "The Coniferæ and Gnetaceæ," as also "On Azolla." This thoughtful naturalist and Charles Martins, of Montpellier, are among the few botanists who have thoroughly understood the fundamental value of the Theory of Descent, and the mechanical-causal connection between ontogeny and phylogeny. The majority of botanists do not even yet know the important difference between homology and analogy, between the morphological and physiological comparison of parts—which has long since been recognized in zoology—but Strasburger has employed this distinction and the principle of evolution in his "Comparative Anatomy of the Gymnosperms," in order to sketch the outlines of the blood relationship of this important group of plants.

The class among Ferns which has developed most directly out of the Liverworts is the class of real Ferns, in the narrow sense of the word, the *Frondose Ferns* (Filices, or Phyllopterides, also called Pteridæ). In the present flora of the temperate zones this class forms only a subordinate part, for it is in most cases represented only by low forms without trunks. But in the torrid zones, especially in the moist, steaming forests of tropical regions, this class presents us with the lofty palm-like *fern trees*. These beautiful tree-ferns of the present day, which form the chief ornament of

our hot-houses, can however give us but a faint idea of the stately and splendid frondose ferns of the primary period, whose mighty trunks, densely crowded together, then formed entire forests. These trunks, accumulated in super-incumbent masses, are found in the coal seams of the Carboniferous period, and between them, in an excellent state of preservation, are found the impressions of the elegant fan-shaped leaves, crowning the top of the trunk in an umbrella-like bush. The varied outlines and the feather-like forms of these fronds, the elegant shape of the branching veins or bunches of vessels in their tender foliage, can still be as distinctly recognized in the impressions of the palæolithic fronds as in the fronds of ferns of the present day. In many cases even the clusters of fruit, which are distributed on the lower surface of the fronds, are distinctly preserved. After the carboniferous period, the predominance of frondose ferns diminished, and towards the end of the secondary period they played almost as subordinate a part as they do at the present time.

The Calamariæ, Ophioglossæ, and Rhizocarpeæ seem to have developed as three diverging branches out of the Frondose Ferns, or Pteridæ. The Calamariæ, or Calamophyta, have remained at the lowest level among these three classes. The Calamariæ comprise three different orders, of which only one now exists, namely, the Horse-tails (Equisetaceæ). The two other orders, the Giant Reeds (Calamitæ), and the Star-leaf Reeds (Asterophyllitæ), are long since extinct. All Calamariæ are characterized by a hollow and jointed stalk, stem, or trunk, upon which the branches and leaves (in cases where they exist) are set so as to encircle the jointed stem in whorls. The hollow joints of the stalk are

separated from one another by partition walls. In Horse-tails and Calamiteæ the surface is traversed by longitudinal ribs running parallel, as in the case of a fluted column, and the outer skin contains so much silicious earth in the living forms, that it is used for cleansing and polishing. In the Asterophylliteæ, the star-shaped whorls of leaves were more strongly developed than in the two other orders. There exist, at present, of the Calamariæ only the insignificant Horse-tails (*Equisetum*), which grow in marshes and on moors; but during the whole of the primary and secondary periods they were represented by great trees of the genus *Equisetites*. There existed, at the same time, the closely related order of the Giant Reeds (*Calamites*), whose strong trunks grew to a height of about fifty feet. The order of the Asterophyllites, on the other hand, contained smaller and prettier plants, of a very peculiar form, and belongs exclusively to the primary period.

Among all Ferns, the history of the third class, that of the *Root*, or *Aquatic Ferns* (*Rhizocarpeæ*, or *Hydropteridæ*), is least known to us. In their structure these ferns, which live in fresh water, are on the one hand allied to the frond ferns, and on the other to the scaly ferns, but they are more closely related to the latter. Among them are the but little known moss ferns (*Salvinia*), clover ferns (*Marsilea*), and pill ferns (*Pilularia*) of our fresh waters; further, the large *Azolla* which floats in tropical ponds. Most of the aquatic ferns are of a delicate nature, and hence ill-suited for being petrified. This is probably the reason of their fossil remains being so scarce, and of the oldest of those known to us having been found in the Jura system. It is probable, however, that the class is much older, and that it

was already developed during the palæolithic period out of other ferns by adaptation to an aquatic life.

The fourth class of ferns is formed by the *Tongue Ferns* (Ophioglossæ, or Glossopterides). These ferns, to which belongs the *Botrychium*, as well as the *Ophioglossum* (adder's-tongue) of our native genera, were formerly considered as forming but a small subdivision of the frondose ferns. But they deserve to form a special class, because they represent important transitional forms from the Pterideæ and Lepidophytes towards higher plants, and must be regarded as among the direct progenitors of the flowering plants.

The fifth and last class is formed by the *Scale Ferns* (Lepidophytes, or Selagines). In the same way as the Ophioglossæ arose out of the frondose forms, the scale ferns arose out of the Ophioglossæ. They were more highly developed than all other ferns, and form the transition to flowering plants, which must have developed out of them. Next to the frondose ferns they took the largest part in the composition of the palæolithic fern forests. This class also contains, as does the class of reed ferns, three nearly related but still very different orders, of which only one now exists, the two others having become extinct towards the end of the carboniferous period. The scaled ferns still existing belong to the order of the club-mosses (Lycopodiaceæ). They are mostly small, pretty moss-like plants, whose tender, many-branched stalk creeps in curves on the ground like a snake, and is densely encompassed and covered by small scaly leaves. The pretty creeping *Lycopodium* of our woods, which mountain tourists twine round their hats, is known to all, as also the still more delicate

Selaginella, which under the name of creeping moss is used to adorn the soil of our hot-houses in the form of a thick carpet. The largest *club-mosses* of the present day are found in the Sunda Islands, where their stalks rise to the height of twenty-five feet, and attain half a foot in thickness. But in the primary and secondary periods even larger trees of this kind were widely distributed, the most ancient of which probably were the progenitors of the pines (*Lycopodites*). The most important dimensions were, however, attained by the class of scale trees (*Lepidodendreæ*), and by the seal trees (*Sigillarieæ*). These two orders, with a few species, appear in the Devonian period, but do not attain their immense and astonishing development until the Carboniferous period, and become extinct towards the end of it, or in the Permian period directly following upon it. The scale trees, or *Lepidodendreæ*, were probably more closely related to club-mosses than to *Sigillarieæ*. They grew into splendid, straight, unbranching trunks which divided at the top into numerous forked branches. They bore a large crown of scaly leaves, and like the trunk were marked in elegant spiral lines by the scars left at the base of the leaf stalks which had fallen off. We know of scale-marked trees from forty to sixty feet in length, and from twelve to fifteen feet in diameter at the root. Some trunks are said to be even more than a hundred feet in length. In the coal are found still larger accumulations of the no less highly developed but more slender trunks of the remarkable seal trees, *Sigillarieæ*, which in many places form the principal part of coal seams. Their roots were formerly described as quite a distinct vegetable form (under the name of *Stigmaria*). The *Sigillarieæ* are in many respects very like

the scale-trees, but differ from them and from ferns in general in many ways. They were possibly closely related to the extinct Devonian *Lycoperideæ*, combining characteristic peculiarities of the club-mosses and the frondose ferns, which Strasburger considers as the hypothetical primary form of flowering plants.

In leaving the dense forests of the primary period, which were principally composed of frond ferns (*Lepidodendreæ* and *Sigillariææ*), we pass onwards to the no less characteristic pine forests of the secondary period. Thus we leave the domain of the Cryptogamia, the plants forming neither flowers nor seeds, and enter the second main division of the vegetable kingdom, namely, the sub-kingdom of the *Phanerogamia*, *flowering plants* forming seeds. This division, so rich in forms, containing the principal portion of the present vegetable world, and especially the majority of plants living on land, is certainly of a much more recent date than the division of Cryptogamia. For it can have developed out of the latter only in the course of the palæolithic period. We can with full assurance maintain that, during the whole archilithic period, hence during the first and longer half of the organic history of the earth, no flowering plants as yet existed, and that they first developed during the primary period out of Cryptogamia of the fern kind. The anatomical and embryological relation of Phanerogamia to the latter is so close, that from it we can with certainty infer their genealogical connection, that is, their true blood relationship. Flowering plants cannot have directly arisen out of thallus plants, nor out of mosses; but only out of ferns, or Filicines. Most probably the scaled ferns, or *Lepidophyta*, and more especially amongst these the *Lycopodiaceæ*, forms

closely related to the *Selaginella* of the present day, have been the direct progenitors of the *Phanerogamia*.

On account of its anatomical structure and its embryological development, the sub-kingdom of the *Phanerogamia* has for a long time been divided into two large branches, into the *Gymnosperms*, or plants with naked seeds, and the *Angiosperms*, or plants with enclosed seeds. The latter are in every respect more perfect and more highly organized than the former, and developed out of them only at a late date during the secondary period. The *Gymnosperms*, both anatomically and embryologically, form the transition group from Ferns to *Angiosperms*.

The lower, more imperfect, and the older of the two main classes of flowering plants, that of the *Archispermeæ*, or *Gymnosperms* (with naked seeds), attained its most varied development and widest distribution during the mesolithic or secondary epoch. It was no less characteristic of this period, than was the fern group of the preceding primary, and the *Angiosperms* of the succeeding tertiary, epoch. Hence we might call the secondary epoch that of *Gymnosperms*, or after its most important representatives, the era of Pine Forests. The *Gymnosperms* are divided into three classes: the *Coniferæ*, *Cycadeæ*, and *Gnetaceæ*. We find fossil remains of the pines, or *Conifers*, and of the *Cycads*, even in coal, and must infer from this that the transition from scaled ferns to *Gymnosperms* took place during the Coal, or possibly even in the Devonian period. However, the *Gymnosperms* play but a very subordinate part during the whole of the primary epoch, and do not predominate over Ferns until the beginning of the secondary epoch.

Of the two classes of *Gymnosperms* just mentioned, that

of the *Palm Ferns* (*Zamiæ*, or *Cycadeæ*) stands at the lowest stage, and is directly allied to ferns, as the name implies, so that some botanists have actually included them in the fern group. In their external form they resemble palms, as well as tree ferns (or tree-like frond ferns), and are adorned by a crown of feathery leaves, which is placed either on a thick, short trunk, or on a slender, simple trunk like a pillar. At the present day this class, once so rich in forms, is but scantily represented by a few forms living in the torrid zones, namely, by the coniferous ferns (*Zamia*), the thick-trunked bread-tree (*Encephalartos*), and the slender-trunked Caffir bread-tree (*Cycas*). They may frequently be seen in hot-houses, and are generally mistaken for palms. A much greater variety of forms than occurs among the still existing palm ferns (*Cycadeæ*) is presented by the extinct and fossil Cycads, which occurred in great numbers more towards the middle of the secondary period, during the Jura, and which at that time principally determined the character of the forests.

The class of *Pines*, or *coniferous trees* (*Coniferæ*), has preserved down to our day a greater variety of forms than have the palm ferns. Even at the present time the trees belonging to it—cypresses, juniper trees, and trees of life (*Thuja*), the box and ginko trees (*Salisburya*), the araucaria and cedars, but above all the genus *Pinus*, which is so rich in forms, with its numerous and important species, spruces, pines, firs, larches, etc.—still play a very important part in the most different parts of the earth, and almost of themselves constitute extensive forests. Yet this development of pines seems but weak in comparison with the predominance which the class had attained over other plants during the early

secondary period, that of the Trias. At that time mighty coniferous trees—with but proportionately few genera and species, but standing together in immense masses of individuals—formed the principal part of the mesolithic forests. This fact justifies us in calling the secondary period the “era of the pine forests,” although the remains of Cycadeæ predominate over those of coniferous trees in the Jura period.*

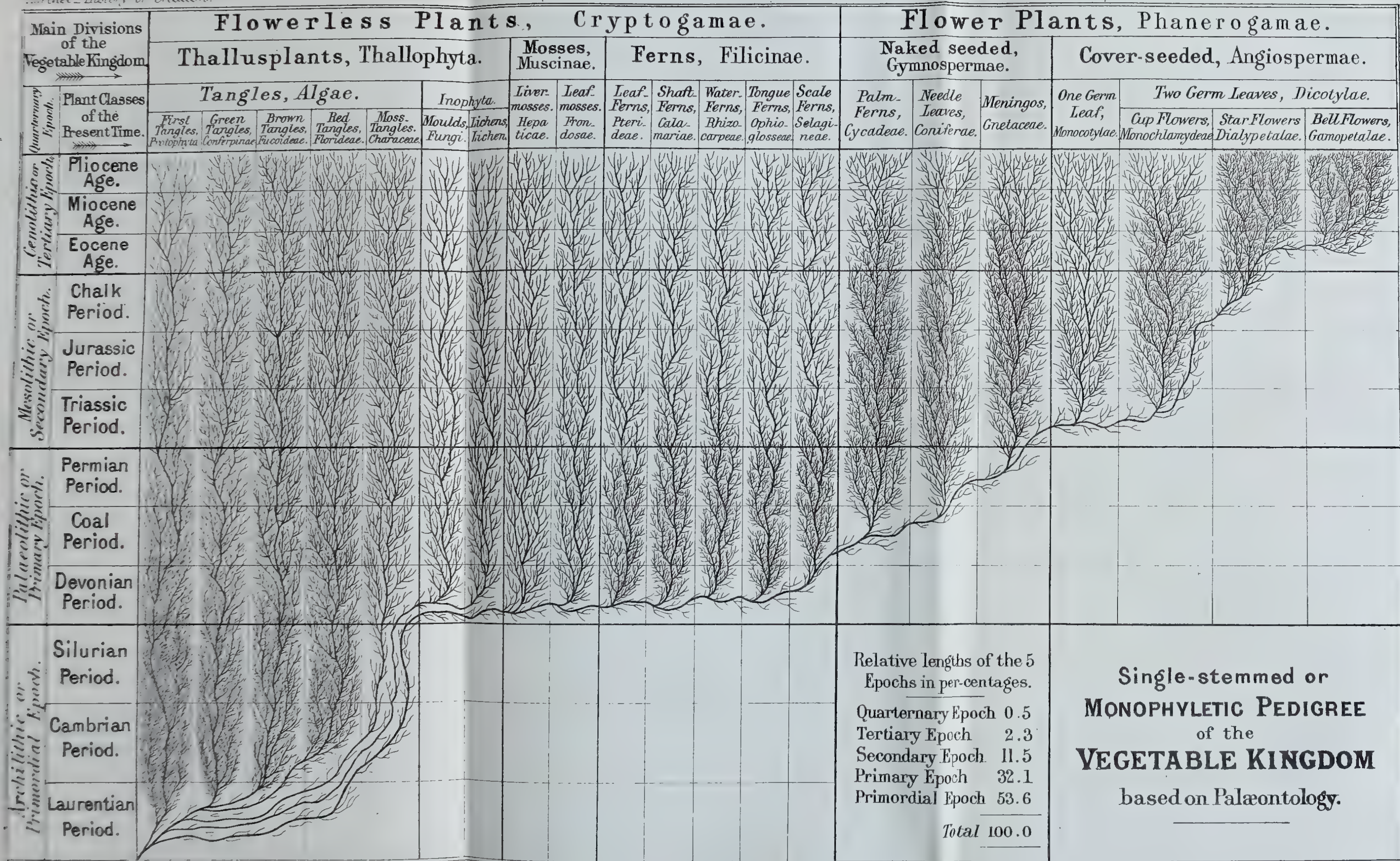
From the pine forests of the mesolithic, or secondary period, we pass on into the leafy forests of the cænolithic, or tertiary period, and we arrive thus at the consideration of the sixth and last class of the vegetable kingdom, that of the *Metaspermæ*, *Angiospermæ*, or *plants with enclosed seeds*. The first certain and undoubted fossils of plants with enclosed seeds are found in the strata of the chalk system, and indeed we here find, side by side, remains of the two classes into which the main class of Angiosperms is generally divided, namely, the *one seed-lobed plants*, or *monocotylæ*, and the *two seed-lobed plants*, or *dicotylæ*. However, the whole group probably originated at an earlier period during the Trias. For we know of a number of doubtful and not accurately definable fossil remains of plants from the Oolitic and Trias (sic) periods, which some botanists consider to be Monocotylæ, whilst others consider them as Gymnosperms. In regard to the two classes of

* The primary stock of the Coniferæ divided into two branches at an early period, into the Arancariæ on the one hand, and the Taxaceæ, or yew-trees, on the other. The majority of recent Coniferæ are derived from the former. Out of the latter the third class of the Gymnosperms—the Meninges, or Gnetaceæ—were developed. This small but very interesting class contains only three different genera—Gnetum, Welwitschia, and Ephedra; it is, however, of great importance, as it forms the transition group from the Coniferæ to the Angiosperms, and more especially to the Dicotyledons.

plants with enclosed seeds, the Monocotylæ and Dicotylæ, it is exceedingly probable that the Dicotyledons developed out of the Gnetaceæ, but that the Monocotyledons developed later out of a branch of the dicotyledons.

The class of *one seed-lobed plants* (Monocotylæ, or Monocotyledons, also called Endogenæ) comprises those flowering plants whose seeds possess but one germ leaf or seed lobe (cotyledon). Each whorl of its flower contains in most cases *three* leaves, and it is very probable that the mother plants of all Monocotyledons possessed a regular triple blossom. The leaves are mostly simple, and traversed by simple, straight bunches of vessels or "nerves." To this class belong the extensive families of the rushes, grasses, lilies, irids, and orchids, further a number of indigenous aquatic plants, the water-onions, sea grasses, etc., and finally the splendid and highly developed families of the Aroideæ and Pandaneæ, the bananas and palms. On the whole, the class of Monocotyledons—in spite of the great variety of forms which it developed, both in the tertiary and the present period—is much more simply organized than the class of the Dicotyledons, and its history of development also offers much less of interest. As their fossil remains are for the most part difficult to recognize, it still remains at present an open question in which of the three great secondary periods—the Trias, Jura, or chalk period—the Monocotyledons originated. At all events they existed in the chalk period as surely as did the Dicotyledons.

The second class of plants with enclosed seeds, the *two seed-lobed* (Dicotylæ, or Dicotyledons, also called Exogenæ) presents much greater historical and anatomical interest in



the development of its subordinate groups. The flowering plants of this class generally possess, as their name indicates, two seed lobes or germ leaves (cotyledons). The number of leaves composing its blossom is generally not three, as in most Monocotyledons, but four, five, or a multiple of those numbers. Their leaves, moreover, are generally more highly differentiated and more composite than those of the Monocotyledons; they are traversed by crooked, branching bunches of vessels or "veins." To this class belong most of the leafed trees, and as they predominate in the tertiary period as well as, at present, over the Gymnosperms and Ferns, we may call the cænolithic period that of leafed forests.

Although the majority of Dicotyledons belong to the most highly developed and most perfect plants, still the lowest division of them is directly allied to the Gymnosperms, and particularly to the Gnetaceæ. In the lower Dicotyledons, as in the case of the Monocotyledons, calyx and corolla are as yet not differentiated. Hence they are called *Apetalous* (Monochlamydeæ, or Apetalæ). This sub-class must therefore doubtless be looked upon as the original group of the Angiosperms, and existed probably even during the Trias and Jura periods. Among them are most of the leafed trees bearing catkins—birches and alders, willows and poplars, beeches and oaks; further, the plants of the nettle kind—nettles, hemp, and hops, figs, mulberries, and elms; finally, plants like the spurges, laurels, and amaranth.

It was not until the chalk period that the second and more perfect class of the Dicotyledons appeared, namely, the *group with corollas* (Dichlamydeæ, or Corollifloræ). These arose out of the Apetalæ from the simple cover of the

blossoms of the latter becoming differentiated into calyx and corolla. The sub-class of the Corollifloræ is again divided into two large main divisions or legions, each of which contains a large number of different orders, families, genera, and species. The first legion bears the name of star-flowers, or Diapetalæ, the second that of the bell-flowers, or Gamopetalæ.

The lower and less perfect of the two legions of the Corollifloræ are the star-flowers (also called Diapetalæ or Dialypetalæ). To them belong the extensive families of the Umbelliferæ, or umbrella-worts (wild carrot, etc.), the Cruciferæ, or cruciform blossoms (cabbage, etc.); further, the Ranunculaceæ (buttercups) and Crassulaceæ, the Mallows and Geraniums, and, besides many others, the large group of Roses (which comprise, besides roses, most of our fruit trees), and the Pea-blossoms (containing, among others, beans, clover, genista, acacia, and mimosa). In all these Diapetalæ the blossom-leaves remain separate, and never grow together, as is the case in the Gamopetalæ. These latter developed first in the tertiary period out of the Diapetalæ, whereas the Diapetalæ appeared in the chalk period together with the Apetalæ.

The highest and most perfect group of the vegetable kingdom is formed by the second division of the Corollifloræ, namely, the legion of bell-flowers (Gamopetalæ, also called Monopetalæ or Sympetalæ). In this group the blossom-leaves, which in other plants generally remain separate, grow regularly together into a more or less bell-like, funnel-shaped, or tubular flower. To them belong, among others, the Bell-flowers and Convolvulus, Primroses and Heaths, Gentian and Honeysuckle, further the family of the Olives (olive trees, privet, elder, and ash), and finally, besides many

other families, the extensive division of the Lip-blossoms (Labiatae) and the Composites. In these last the differentiation and perfection of the Phanerogamic blossoms attain their highest stage of development, and we must therefore place them at the head of the vegetable kingdom, as the most perfect of all plants. In accordance with this, the legion of the Gamopetalae appear in the organic history of the earth later than all the main groups of the vegetable kingdom—in fact, not until the cænolithic or tertiary epoch. In the earliest tertiary period the legion is still very rare, but it gradually increases in the mid-tertiary, and attains its full development only in the latest tertiary and the quaternary period.

Now if, having reached our own time, we look back upon the *whole history of the development of the vegetable kingdom*, we cannot but perceive in it a *grand confirmation of the Theory of Descent*. The two great principles of organic development which have been pointed out as the necessary results of natural selection in the Struggle for Life, namely, the laws of *differentiation* and *perfecting*, manifest themselves everywhere in the development of the larger and smaller groups of the natural system of plants. In each larger or smaller period of the organic history of the earth, the vegetable kingdom increases both in *variety* and *perfection*, as a glance at Plate IV. will clearly show. During the whole of the long primordial period there existed only the lowest and most imperfect group, that of the Algæ. To these are added, in the primary period, the higher and more perfect Cryptogamia, especially the main-class of Ferns. During the coal period the Phanerogamia begin to develop out of the latter; at first, however, they are represented only

by the lower main-class, that of Gymnosperms. It was not until the secondary period that the higher main-class, that of Angiosperms, arose out of them. Of these also there existed at first only the lower groups without distinct corollas, the Monocotyledons and the Apetalæ. It was not until the chalk period that the higher Corollifloræ developed out of the latter. But even this most highly developed group is represented, in the chalk period, only by the lower stage of Star-flowers, or Diapetalæ, and only at quite a late date, in the tertiary period, did the more highly developed Bell-blossoms, Gamopetalæ, arise out of them, which at the same time are the most perfect of all flowering plants. Thus, in each succeeding later division of the organic history of the earth the vegetable kingdom gradually rose to a higher degree of perfection and variety.

CHAPTER XVIII.

PEDIGREE AND HISTORY OF THE ANIMAL KINGDOM.

I. ANIMAL-PLANTS AND WORMS.

The Natural System of the Animal Kingdom.—Linnæus and Lamarck's Systems.—The Four Types of Bär and Cuvier.—Their Increase to Seven Types.—Genealogical Importance of the Seven Types as Independent Tribes of the Animal Kingdom.—Derivation of Zoophytes and Worms from Primæval Animals.—Monophyletic and Polyphyletic Hypothesis of the Descent of the Animal Kingdom.—Common Origin of the Four Higher Animal Tribes out of the Worm Tribe.—Division of the Seven Animal Tribes into Sixteen Main Classes, and Thirty-eight Classes.—Primæval Animals (Monera, Amœbæ, Synamœbæ), Gregarines, Infusoria, Planæades, and Gastræades (Planula and Gastrula).—Tribe of Zoophytes.—Spongiæ (Mucous Sponges, Fibrous Sponges, Calcareous Sponges).—Sea Nettles, or Acalephæ Corals, Hood-jellies, Comb-jellies).—Tribe of Worms.

THE natural system of organisms which we must employ in the animal as well as in the vegetable kingdom, as a guide in our genealogical investigations, is in both cases of but recent origin, and essentially determined by the progress of comparative anatomy and ontogeny (the history of individual development) during the present century. Almost all the attempts at classification made in the last century followed the path of the artificial system, which was first established in a consistent manner by Charles

Linnæus. The artificial system differs essentially from the natural one, in the fact that it does not make the whole organization and the internal structure (depending upon the blood relationship) the basis of classification, but only employs individual, and for the most part external, characteristics, which readily strike the eye. Thus Linnæus distinguished his twenty-four classes of the vegetable kingdom principally by the number, formation, and combination of the stamens. In like manner he distinguished six classes in the animal kingdom principally by the nature of the heart and blood. These six classes were: (1) Mammals; (2) Birds; (3) Amphibious Animals; (4) Fishes; (5) Insects; and (6) Worms.

But these six animal classes of Linnæus are by no means of equal value, and it was an important advance when, at the end of the last century, Lamarck comprised the first four classes as vertebrate animals (Vertebrata), and put them in contrast with the remaining animals (the insects and worms of Linnæus), of which he made a second main division—the invertebrate animals (Invertebrata). In reality Lamarck thus agreed with Aristotle, the father of Natural History, who had distinguished these two main groups, and called the former *blood-bearing animals*, the latter *bloodless animals*.

The next important progress towards a natural system of the animal kingdom was made some decades later by two most illustrious zoologists, Carl Ernst Bär and George Cuvier. As has already been remarked, they established, almost simultaneously and independently of one another, the proposition that it was necessary to distinguish several completely distinct main groups in the animal kingdom, each of

which possessed an entirely peculiar type or structure (compare above, vol. i. p. 53). In each of these main divisions there is a tree-shaped and branching gradation from most simple and imperfect forms to those which are exceedingly composite and highly developed. The *degree of development* within each type is quite independent of the peculiar *plan of structure*, which forms the basis of the type and gives it a special characteristic. The "type" is determined by the peculiar relations in position of the most important parts of the body, and the manner in which the organs are connected. The degree of development, however, is dependent upon the greater or less division of labour among organs, and on the differentiation of the plastids and organs. This extremely important and fruitful idea was established by Bär, who relied more distinctly and thoroughly upon the history of individual development than did Cuvier. Cuvier based his argument upon the results of comparative anatomy. But neither of them recognized the true cause of the remarkable relationships pointed out by them, which is first revealed to us by the Theory of Descent. It shows us that the common *type* or plan of structure is determined by *inheritance*, and the degree of development or differentiation by *adaptation*. (Gen. Morph. ii. 10).

Both Bär and Cuvier distinguished four different types in the animal kingdom, and divided it accordingly into four great main divisions (branches or circles). The first of these is formed by the vertebrate animals (Vertebrata), and comprises Linnæus' first four classes—mammals, birds, amphibious animals, and fishes. The second type is formed by the articulated animals (Articulata), containing Linnæus' insects, consequently the six-legged insects, and also the

myriopods, spiders, and crustacea, but besides these, a large number of the worms, especially the ringed worms. The third main division comprises the molluscous animals (Mollusca)—slugs, snails, mussels, and some kindred groups. Finally, the fourth and last circle of the animal kingdom comprises the various radiated animals (Radiata), which at first sight differ from the three preceding types by their radiated, flower-like form of body. For while the bodies of molluscs, articulated animals, and vertebrated animals consist of two symmetrical lateral halves—of two counterparts or antimeræ, of which the one is the mirror of the other—the bodies of the so-called radiated animals are composed of more than two, generally of four, five, or six counterparts grouped round a common central axis, as in the case of a flower. However striking this difference may seem at first, it is, in reality, a very subordinate one, and the radial form has by no means the same importance in all “radiated animals.”

The establishment of these natural main groups or types of the animal kingdom by Bär and Cuvier was the greatest advance in the classification of animals since the time of Linnæus. The three groups of vertebrated animals, articulated animals, and molluscs are so much in accordance with nature that they are retained, even at the present day, little altered in extent. But a more accurate knowledge soon showed the utterly unnatural character of the group of the radiated animals. Leuckart, in 1848, first pointed out that two perfectly distinct types were confounded under the name, namely, the *Star-fishes* (Echinoderma)—the sea-stars, lily encrinites, sea-urchins, and sea-cucumbers; and, on the other hand, the *Animal-plants*, or *Zoophytes* (Coelenterata,

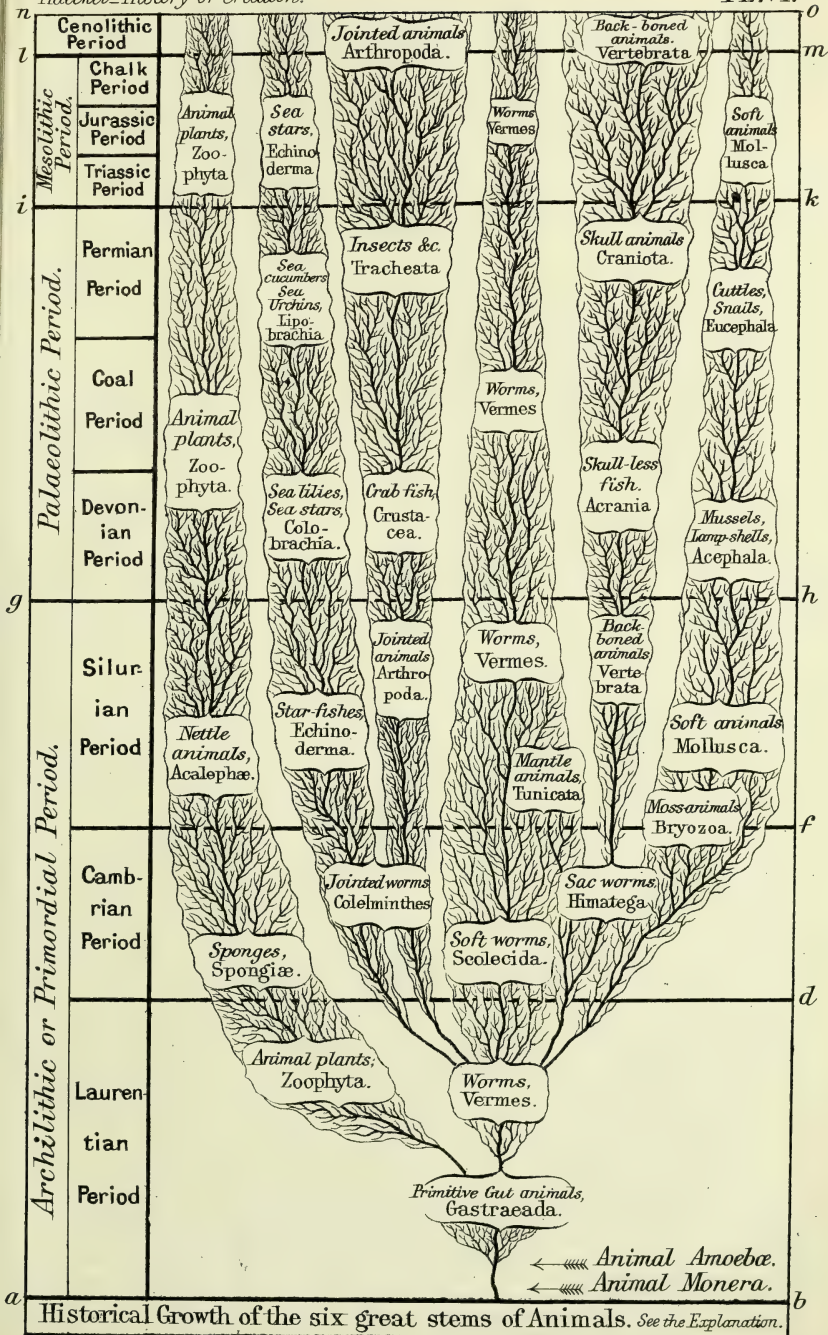
or Zoophyta)—the sponges, corals, hood-jellies, and comb-jellies. At the same time, Siebold united the Infusoria with the Rhizopoda, under the name of Protozoa (lowest animals), into a special main division of the animal kingdom. By this the number of animal types was increased to six. It was finally increased to seven by the fact that modern zoologists separated the main division of the articulated animals into two groups: (*a*) those possessing *articulated feet* (Arthropoda), corresponding to Linnæus' Insects, namely, the Flies (with six legs), Myriopods, Spiders, and Crustacea; and (*b*) the footless *Worms* (Vermes), or those possessing non-articulated feet. These latter comprise only the real or genuine Worms (ring-worms, round worms, planarian worms, etc.), and therefore in no way correspond with the Worms of Linnæus, who had included the molluscs, the radiates, and many other lower animals under this name.

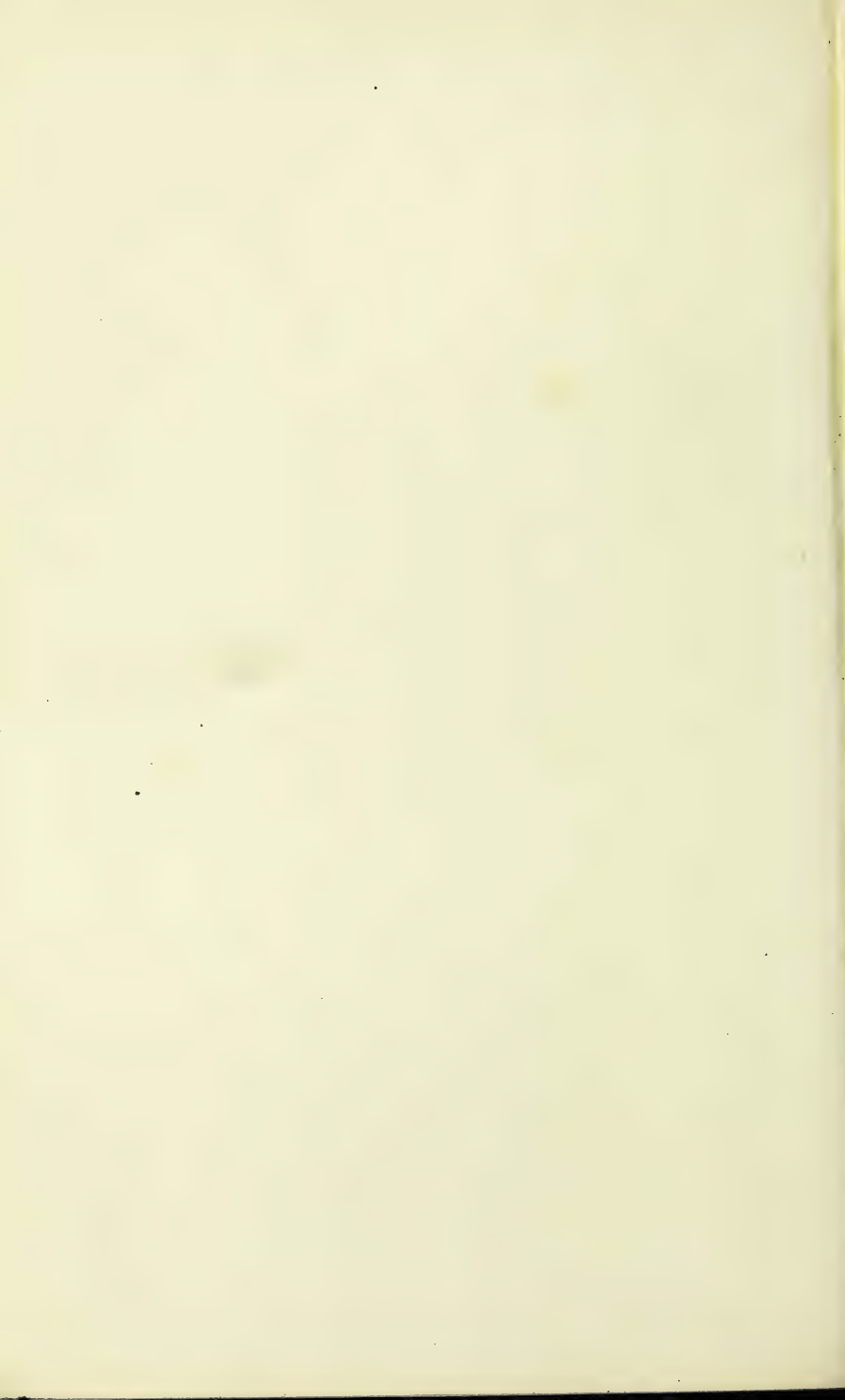
Thus, according to the views of modern zoologists, which are given in all recent manuals and treatises on zoology, the animal kingdom is composed of seven completely distinct main divisions or types, each of which is distinguished by a characteristic plan of structure peculiar to it, and perfectly distinct from every one of the others. In the natural system of the animal kingdom—which I shall now proceed to explain as its probable pedigree—I shall on the whole agree with this usual division, but not without some modifications, which I consider very important in connection with genealogy, and which are rendered absolutely necessary in consequence of our view as to the history of the development of animals.

We evidently obtain the greatest amount of information concerning the *pedigree of the animal kingdom* (as well as concerning that of the vegetable kingdom) from comparative

anatomy and ontogeny. Besides these, palæontology also throws much valuable light upon the historical succession of many of the groups. From numerous facts in comparative anatomy, we may, in the first place, infer the *common origin of all those animals which belong to one of the seven "types."* For in spite of all the variety in the external form developed within each of these types, the essential relative position of the parts of the body which determines the type, is so constant, and agrees so completely in all the members of every type, that on account of their relations of form alone we are obliged to unite them, in the natural system, into a single main group. But we must certainly conclude, moreover, that this conjunction also has its expression in the pedigree of the animal kingdom. For the true cause of the intimate agreement in structure can only be the actual blood relationship. Hence we may, without further discussion, lay down the important proposition that all animals belonging to one and the same circle or type must be descended from one and the same original primary form. In other words, the idea of the circle or type, as it is employed in zoology since Bär and Cuvier's time to designate the few principal main groups or "sub-kingdoms" of the animal kingdoms, coincides with the idea of "tribe" or "phylum," as employed by the Theory of Descent.

If, then, we can trace all the varieties of animal forms to these seven fundamental forms, the following question next presents itself to us as a second phylogenetic problem—Where do these seven animal tribes come from? Are they seven original primary forms of an entirely independent origin, or are they also distantly related by blood to one another?





At first we might be inclined to answer this question in a *polyphyletic* sense, by saying that we must assume, for each of the seven great animal tribes, at least one independent primary form completely distinct from the others. On further considering this difficult problem, we arrive in the end at the notion of a *monophyletic* origin of the animal kingdom, viz., that these seven primary forms are connected at their lowest roots, and that they are derived from a single, common primæval form. *In the animal as well as in the vegetable kingdom, when closely and accurately considered, the monophyletic hypothesis of descent is found to be more satisfactory than the polyphyletic hypothesis.*

It is *comparative ontogeny* (embryology) which first and foremost leads to the assumption of the monophyletic origin of the whole animal kingdom (the Protista excepted of course). The zoologist who has thoughtfully compared the history of the individual development of various animals, and has understood the importance of the biogenetic principle (p. 33), cannot but be convinced that a common root must be assumed for the seven different animal tribes, and that all animals, including man, are derived from a single, common primary form. The result of the consideration of the facts of embryology, or ontogeny, is the following genealogical or phylogenetic hypothesis, which I have put forward and explained in detail in my "Philosophy of Calcareous Sponges" (Monograph of the Calcareous Sponges, vol. i. pp. 464, 465, etc.,—"the Theory of the Layers of the Embryo, and the Pedigree of Animals.")

The first stage of organic life in the Animal kingdom (as in the Vegetable and Protista kingdoms) was formed by perfectly simple *Monera*, originating by spontaneous generation.

The former existence of this simplest animal form is, even at present, attested by the fact that the egg-cell of many animals loses its kernel directly after becoming fructified, and thus relapses to the lower stage of development of a cytod without a kernel, like a Moneron. This remarkable occurrence I have interpreted, according to the law of latent inheritance (vol. i. p. 205), as a phylogenetic *relapse* of the cellular form into the original form of a cytod. The *Monerula*, as we may call this egg-cytod without a kernel, repeats then, according to the biogenetic principle (vol. ii. p. 33), the most ancient of all animal forms, the common primary form of the animal kingdom, namely, the Moneron.

The second ontogenetic process consists in a new kernel being formed in the Monerula, or egg-cytod, which thus returns again to the value of a true *egg-cell*. According to this, we must look upon the simple animal cell, containing a kernel, or the single-celled primæval animal—which may still be seen in a living state in the *Amœbæ* of the present day—as the *second* step in the series of phylogenetic forms of the animal kingdom. Like the still living simple *Amœbæ*, and like the naked egg-cells of many lower animals (for example, of Sponges and Medusæ, etc.), which cannot be distinguished from them, the remote phyletic primary *Amœbæ* also were perfectly simple naked-cells, which moved about in the Laurentian primæval ocean, creeping by means of the ever-changing processes of their body-substance, and nourishing and propagating themselves in the same way as the *Amœbæ* of the present day. (Compare vol. i. p. 188, and vol. ii. p. 54.) The existence of this *Amœba-like, single-celled primary form* of the whole animal kingdom is unmistakably indicated by the exceedingly im-

portant fact that the egg of all animals, from those of sponges and worms up to those of the ant and man, is a simple cell.

Thirdly, from the "single-cell" state arose the *simplest multicellular state*, namely, a heap or a small community of simple, equiformal, and equivalent cells. Even at the present day, in the ontogenetic development of every animal egg-cell, there first arises a globular heap of equiformal naked cells, by the repeated self-division of the primary cell. (Compare vol. i. p. 190 and the Frontispiece, Fig. 3.) We called this accumulation of cells the *mulberry state* (Morula), because it resembles a mulberry or blackberry. This Morula-body occurs in the same simple form in all the different tribes of animals, and on account of this most important circumstance we may infer—according to the biogenetic principle—that the *most ancient, many-celled, primary form of the animal kingdom* resembled a Morula like this, and was in fact a simple heap of Amœba-like primæval cells, one similar to the other. We shall call this most ancient community of Amœbæ—this most simple accumulation of animal cells—which is recapitulated in individual development by the Morula—the *Synamœba*.

Out of the Synamœbæ, in the early Laurentian period, there afterwards developed a fourth primary form of the animal kingdom, which we shall call the ciliated germ (Planæa). This arose out of the Synamœba by the outer cells on the surface of the cellular community beginning to extend vibrating fringes called cilia, and becoming "ciliated cells," and thus differentiating from the inner and unchanged cells. The Synamœbæ consisted of completely equiformed and naked cells, and crept about slowly, at the bottom of the Laurentian primæval ocean, by means

of movements like those of an *Amœba*. The *Planæa*, on the other hand, consisted of two kinds of different cells—inner ones like the *Amœbæ*, and external “ciliated cells.” By the vibrating movements of the cilia the entire multicellular body acquired a more rapid and stronger motion, and passed over from the creeping to the swimming mode of locomotion. In exactly the same manner the *Morula*, in the ontogenesis of lower animals, still changes into a ciliated form of larva, which has been known, since the year 1847, under the name of *Planula*. This *Planula* is sometimes a globular, sometimes an oval body, which swims about in the water by means of a vibrating movement; the fringed (ciliated) and smaller cells of the surface differ from the larger inner cells, which are unfringed. (Fig. 4 of the Frontispiece.)

Out of this *Planula*, or fringed larva, there then develops, in animals of all tribes, an exceedingly important and interesting animal form, which, in my Monograph of the Calcareous Sponges, I have named *Gastrula* (that is, larva with a stomach or intestine). (Frontispiece, Fig. 5, 6). This *Gastrula* externally resembles the *Planula*, but differs essentially from it in the fact that it encloses a cavity which opens to the outside by a mouth. The cavity is the “*primary intestine*,” or “primary stomach,” the *progaster*; the first beginning of the alimentary canal; its opening is the “*primary mouth*” (prostoma). The wall of the *progaster* consists of two layers of cells: an outer layer of smaller ciliated cells (outer skin, or ectoderm), and of an inner layer of larger non-ciliated cells (inner skin, or entoderm). This exceedingly important larval form, the “*Gastrula*,” makes its appearance in the ontogenesis of all tribes of

Definition of the forms of the five first stages of the development of the animal body.

Ontogenesis.
The five first stages of the individual development.

Phylogenesis.
The five first stages of the phyletic or historical development.

First Stage of Development.

A simple cytod (a plastid without a kernel.)

Second Stage of Development.

A simple cell (a plastid containing a kernel.)

Third Stage of Development.

A community (an aggregation of identical simple cells).

Fourth Stage of Development.

A solid or bladder-shaped, globular, or oval body, composed of two kinds of different cells: externally ciliated, internally non-ciliated cells.

Fifth Stage of Development.

A globular or oval body with simple intestinal cavity and mouth-opening. Body wall composed of two layers; an externally ciliated ectoderm (dermal layer), an internally non-ciliated entoderm (gastrallayer).

1.

Monerula.

Animal egg without a kernel (when the egg-kernel has disappeared, after being fructified).

2.

Ovulum.

Animal egg with kernel (a simple egg-cell).

3.

Morula.

(Mulberry form.)

Globular heap of homogeneous "cleavage spheres."

4.

Planula.

(Ciliated larva.)

Many-celled larva without mouth, composed of different cells.

5.

Gastrula.

(Larva with mouth.)

Many-celled with intestines and mouth; intestinal wall with two layers.

1.

Moneron.

Most ancient animal Monera, originating by spontaneous generation.

2.

Amœba.

Animal Amœbæ.

3.

Synamœba.

An aggregation of Amœbæ.

4.

Planæa.

Many-celled primitive animal without mouth, composed of two kinds of different cells.

5.

Gastræa.

Many-celled primitive animal with intestine and mouth; intestinal wall with two layers. (Primary form of zoophytes and worms.)

animals—in Sponges, Medusæ, Corals, Worms, Sea-squirts, Radiated animals, Molluscs, and even in the lowest Vertebrata (Amphioxus : compare p. 200, Plate XII., Fig. *B* 4 ; see also in the same place the Ascidian, Fig. *A* 4).

From the ontogenetic occurrence of the Gastrula in the most different animal classes, from Zoophytes up to Vertebrata, we may, according to the biogenetic principle, safely draw the conclusion that during the Laurentian period there existed a common primary form of the six higher animal tribes, which in all essential points was formed like the Gastrula, and which we shall call the Gastræa. This Gastræa possessed a perfectly simple globular or oval body, which enclosed a simple cavity of like form, namely, the progaster ; at one of the poles of the longitudinal axis the primary intestine opened by a mouth which served for the reception of nutrition. The body wall (which was also the intestinal wall) consisted of two layers of cells, the unfringed entoderm, or intestinal layer, and the fringed ectoderm, or skin-layer ; by the motion of the cilia or fringes of the latter the Gastræa swam about freely in the Laurentian ocean. Even in those higher animals, in the ontogenesis of which the original Gastrula form has disappeared, according to the laws of abbreviated inheritance (vol. i. p. 212), the composition of the Gastræa body has been transmitted to the phase of development which directly arises out of the Morulá. This phase is an oval or round disc consisting of two cell-layers or membranes : the outer cell-layer, the *animal or dermal layer* (ectoblast), corresponds to the ectoderm of the Gastræa ; out of it develops the external, loose skin (epidermis), with its glands and appendages, as well as the central nervous system. The inner cell-layer, the

vegetative or intestinal layer (hypoblast), is originally the entoderm of the Gastræa; out of it develops the inner membrane (epithelium) of the intestinal canal and its glands. (Compare my Monograph of the Calcareous Sponges, vol. i. p. 466, etc.)

By ontogeny we have already gained five primordial stages of development of the animal kingdom: (1) the Moneron; (2) the Amœba; (3) the Synamœba; (4) the Planæa; and (5) the Gastræa. The former existence of these five oldest primary forms, which succeeded one another, and which must have lived in the Laurentian period, follows as a consequence of the biogenetic principle; that is to say, from the parallelism and the mechanico-causal connection of ontogenesis and phylogenesis. (Compare vol. i. p. 309.) In our genealogical system of the animal kingdom we may class all these animal forms, long since extinct, and, which on account of the soft nature of their bodies could leave no fossil remains, among the tribe of Primæval animals (Protozoa), which also comprises the still living Infusoria and Gregarinæ.

The phyletic development of the six higher animal tribes, which are all derived from the Gastræa, deviated at this point in two directions. In other words, the *Gastræads* (as we may call the group of forms characterized by the Gastræa-type of structure), divided into two divergent lines or branches; the one branch of Gastræads gave up free locomotion, adhered to the bottom of the sea, and thus, by adopting an adhesive mode of life, gave rise to the *Protascus*, the common primary form of the *Animal-plants* (Zoophyta). The other branch of the Gastræads retained free locomotion, did not become adherent, and later on

developed into the *Prothelmis*, the common primary form of *Worms* (Vermes). (Compare p. 133.)

This latter tribe (as limited by modern zoology) is of the greatest interest in the study of genealogy. For among Worms, as we shall see later, there are, besides very numerous peculiar families, and besides many independent classes, also very remarkable forms, which may be considered as *forms of direct transition* to the four higher animal tribes. Both comparative anatomy and the ontogeny of these worms enable us to recognize in them the nearest blood relations of those extinct animal forms which were the original primary forms of the four higher animal tribes. Hence these latter, the Molluscs, Star-fishes, Articulated animals, and Vertebrate animals, do not stand in any close blood relationship to one another, but have originated independently in four different places out of the tribe of Worms.

In this way comparative anatomy and phylogeny lead us to the *monophyletic pedigree of the animal kingdom*, the outlines of which are given on p. 133. According to it the seven phyla, or tribes, of the animal kingdom are of different value in regard to genealogy. The original primary group of the whole animal kingdom is formed by the Primæval animals (Protozoa), including the Infusoria and Gastræads. Out of these latter arose the two tribes of Animal-plants (Zoophyta) and Worms as diverging branches. Out of four different groups of the Worm tribe, the four higher tribes of the animal kingdom were developed — the Star-fishes (Echinoderma) and Insects (Arthropoda) on the one hand, and the Molluscs (Mollusca) and Vertebrated animals (Vertebrata) on the other.

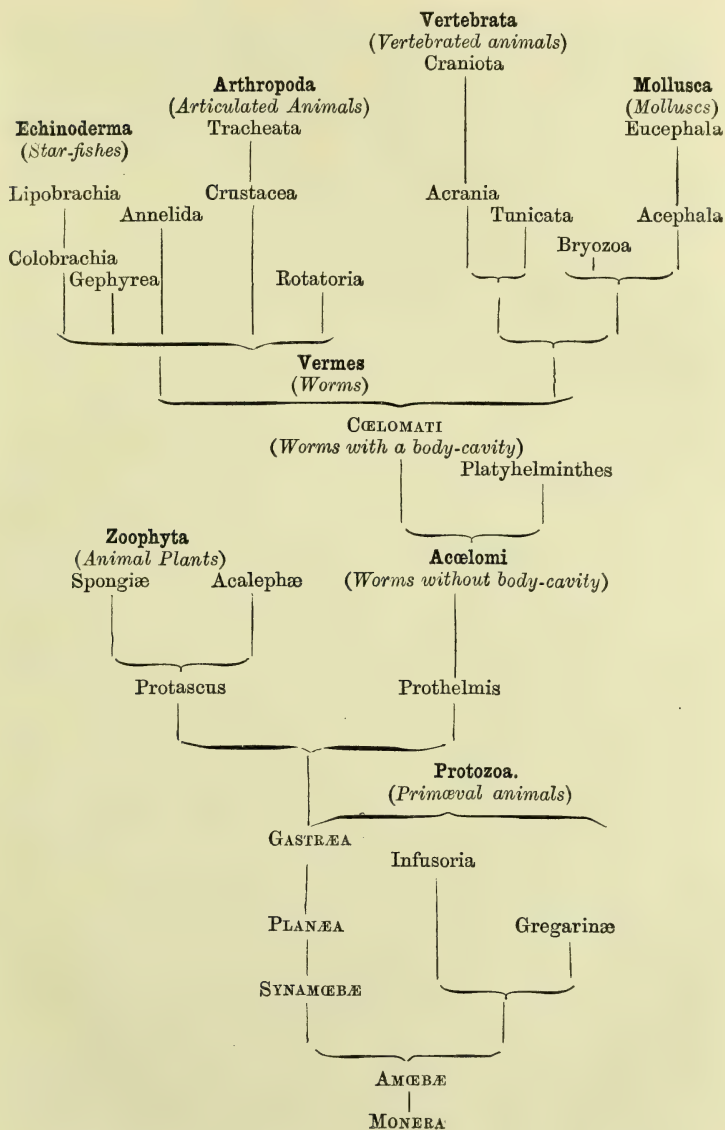
Having thus sketched out the monophyletic pedigree of the animal kingdom in its most important features, we must now turn to a closer examination of the historical course of development which the seven tribes of the animal kingdom, and the classes distinguished in them, have passed through (p. 132). There is a much larger number of classes in the animal than in the vegetable kingdom, owing to the simple reason that the animal body, in consequence of its more varied and perfect vital activity, could differentiate and develop in very many more different directions than could the vegetable body. Thus, while we were able to divide the whole vegetable kingdom into six main classes and nineteen classes, we have to distinguish, at least, sixteen main classes and thirty-eight classes in the animal kingdom. These are distributed among the seven different tribes of the animal kingdom in the way shown in the Systematic Survey on pages 132 and 133.

The group of *Primæval animals* (Protozoa) within the compass which we here assign to this tribe, comprises the most ancient and the simplest primary forms of the animal kingdom; for example, the five oldest phyletic stages of development previously mentioned, and besides these the Infusoria and Gregarinæ, as well as all those imperfect animal forms, for which, on account of their simple and indifferent organization, no place can be found in any of the other six animal tribes. Most zoologists, in addition to these, include among the Protozoa a larger or smaller portion of those lowest organisms, which we mentioned in our neutral kingdom of Protista (in Chapter XVI.). But these Protista, especially the large division of the Rhizopoda, which are so rich in forms, cannot be considered as real animals for

SYSTEMATIC SURVEY

Of the 16 Main Classes and 38 Classes of the Animal Kingdom.

<i>Tribes or Phyla of the Animal Kingdom.</i>	<i>Main Classes, Branches or Clades of the Animal Kingdom.</i>	<i>Classes of the Animal Kingdom.</i>	<i>Systematic Name of the Classes.</i>
A. Primæval Animals Protozoa	{ I. Egg-animals <i>Ovularia</i> II. Mulberry animals <i>Blastularia</i>	{ 1. Archaic animals 2. Gregarines 3. Infusoria 4. Planæads 5. Gastræads	1. Archezoa 2. Gregarinæ 3. Infusoria 4. Planæadas 5. Gastræadas
B. Animal Plants Zoophyta	{ III. Sponges <i>Spongiæ</i> IV. Sea-nettles <i>Acalephæ</i>	{ 6. Sponges 7. Corals 8. Hood-jellies 9. Comb-jellies	6. Porifera 7. Coralla 8. Hydromedusæ 9. Ctenophora
C. Worms Vermes	{ V. Bloodless worms <i>Acalomi</i> VI. Blood-bearing worms <i>Celomati</i>	{ 10. Planary worms 11. Round worms 12. Moss-polyps 13. Sac-worms 14. Proboscideans 15. Star-worms 16. Wheel animal- cules 17. Ring-worms	10. Platyhelminthes 11. Nemathelminthes 12. Bryozoa 13. Tunicata 14. Rhynchocœla 15. Gephyrea 16. Rotatoria 17. Annelida
D. Molluscs Mollusca	{ VII. Headless shell- fish <i>Acephala</i> VIII. Head-bearing <i>Eucephala</i>	{ 18. Lamp-shells 19. Mussels 20. Snails 21. Cuttles	18. Spirobranchia 19. Lamellibranchia 20. Cochlides 21. Cephalopoda
E. Star-fishes Echinoderma	{ IX. Ringed-arms <i>Colobrachia</i> X. Armless <i>Lipobrachia</i>	{ 22. Sea-stars 23. Lily-stars 24. Sea-urchins 25. Sea-cucumbers	22. Asterida 23. Crinoida 24. Echinida 25. Holothuriæ
F. Articulated Animals Arthropoda	{ XI. Gill-breathers <i>Carides</i> XII. Tube-breathers <i>Tracheata</i>	{ 26. Crab-fish 27. Spiders 28. Centipedes 29. Flies	26. Crustacea 27. Arachnida 28. Myriopoda 29. Insecta
G. Vertebrate Animals Vertebrata	{ XIII. Skull-less <i>Acrania</i> XIV. Single-nos- triled <i>Monorrhina</i> XV. Amnion-less <i>Anamnia</i> XVI. Amnion- bearing <i>Amniota</i>	{ 30. Lancelets 31. Lampreys 32. Fishes 33. Mud-fish 34. Sea-dragons 35. Amphibians 36. Reptiles 37. Birds 38. Mammals.	30. Leptocardia 31. Cyclostoma 32. Pisces 33. Dipneusta 34. Hallsauria 35. Amphibia 36. Reptilia 37. Aves 38. Mammalia



reasons previously given. Hence, if we here leave them out of the question, we may accept two main classes or provinces of real Protozoa, namely, *Egg animals* (Ovularia) and *Germ animals* (Blastularia). To the former belong the three classes of Archezoa, Gregarinæ, and Infusoria, to the latter the two classes of Planæads and Gastræads.

The first province of the Protozoa consists of the *Egg animals* (Ovularia); we include among them all *single-celled animals*, all animals whose body, in the fully developed state, possesses the form-value of a *simple plastid* (of a cytod or a cell), also those simple animal forms whose body consists of an aggregation of several cells perfectly similar one to another.

The *Archaic animals* (Archezoa) form the first class in the series of Egg animals. It contains only the most simple and most ancient primary forms of the animal kingdom, whose former existence we have proved by means of the fundamental law of biogenesis; they are, (1) Animal Monera; (2) Animal Amœbæ; (3) Animal Synamœbæ. We may, if we choose, include among them a portion of the still living Monera and Amœbæ, but another portion (according to the discussion in Chapter XVI.) must on account of their neutral nature be considered as Protista, and a third portion, on account of their vegetable nature, must be considered as plants.

A second class of the egg animals consists of the *Gregarines* (Gregarinæ), which live as parasites in the intestines and body-cavities of many animals. Some of these Gregarines are perfectly simple cells like the Amœbæ; some form chains of two or three identical cells, one lying behind the other. They differ from the naked Amœbæ by possessing

a thick, simple membrane, which surrounds their cell-body ; they can be considered as animal Amœbæ which have adopted a parasitical mode of life, and in consequence have surrounded themselves with a secreted covering.

As a third class of egg animals, we adopt the real *Infusoria* (Infusoria), embracing those forms to which modern zoology almost universally limits this class of animals. The principal portion of them consists of the small *ciliated Infusoria* (Ciliata), which inhabit all the fresh and salt waters of the earth in great numbers, and which swim about by means of a delicate garb of vibratile fringes. A second and smaller division consists of the adherent *sucking Infusoria* (Acinetæ), which take their food by means of fine sucking-tubes. Although during the last thirty years numerous and very careful investigations have been made on these small animalcules,—which are mostly invisible to the naked eye,—still we are even now not very sure about their development and form-value. We do not even yet know whether the Infusoria are single or many-celled ; but as no investigator has as yet proved their body to be a combination of cells, we are, in the mean time, justified in considering them as single-celled, like the Gregarines and the Amœbæ.

The second main class of primæval animals consists of the *Germ animals* (Blastularia). This name we give to those extinct Protozoa which correspond to the two ontogenetic embryonic forms of the six higher animal tribes, namely, the Planula and the Gastrula. The body of these Blastularia, in a perfectly developed state, was composed of many cells, and these cells moreover differentiated—in two ways at least—into an external (animal or dermal) and an internal

(vegetative or gastral) mass. Whether there still exist representatives of this group is uncertain. Their former existence is undoubtedly proved by the two exceedingly important ontogenetic animal forms which we have already described as *Planula* and *Gastrula*, and which still occur as a transient stage of development in the ontogeny of the most different tribes of animals. Corresponding to these, we may, according to the biogenetic principle, assume the former existence of two distinct classes of *Blastularia*, namely, the *Planœada* and *Gastrœada*. The type of the *Planœada* is the *Planœa*—long since extinct—but whose historical portrait is still presented to us at the present day in the widely distributed *ciliated larva* (*Planula*). (Frontispiece, Fig. 4.) The type of the *Gastrœada* is the *Gastrœa*, of whose original nature the mouth-and-stomach larva (*Gastrula*), which recurs in the most different animal tribes, still gives a faithful representation. (Frontispiece Fig. 5, 6.) Out of the *Gastrœa*, as we have previously mentioned, there were at one time developed two different primary forms, the *Protascus* and *Prothelmis*; the former must be looked upon as the primary form of the *Zoophytes*, the latter as the primary form of *Worms*. (Compare the enunciation of this hypothesis in my *Monograph of the Calcareous Sponges*, vol. i. p. 464.)

The *Animal-plants* (*Zoophyta*, or *Cœlenterata*) which constitute the second tribe of the animal kingdom, rise considerably above the primitive animals in the characters of their whole organisation, while they remain far below most of the higher animals. For in the latter (with the exception only of the lowest forms) the four distinct functions of nutrition—namely, digestion, circulation of the blood, respiration, and excretion—are universally accomplished by

four perfectly different systems of organs; by the intestines, the vascular system, the organs of respiration, and the urinary apparatus. In Zoophytes, however, these functions and their organs are not yet separate, and are all performed by a single system of alimentary canals, by the so-called gastro-vascular system, or the coelenteric apparatus of the intestinal cavity. The mouth, which is also the anus, leads into a stomach, into which the other cavities of the body also open. In Zoophytes the body-cavity, or "coeloma," possessed by the four higher tribes of animals is still completely wanting, likewise the vascular system and blood, as also the organs of respiration, etc.

All Zoophytes live in water; most of them in the sea, only a very few in fresh water, such as fresh-water sponges (*Spongilla*) and some primæval polyps (*Hydra*, *Cordylophora*). A specimen of the pretty flower-like forms which are met with in great variety among Zoophytes is given on Plate VII. (Compare its explanation in the Appendix.)

The tribe of animal-plants, or Zoophytes, is divided into two distinct provinces, the *Sponges*, or *Spongiæ*, and the *Sea-nettles*, or *Acalephæ* (p. 144). The latter are much richer in forms and more highly organized than the former. In all Sponges the entire body, as well as the individual organs, are differentiated and perfected to a much less extent than in Sea-nettles. All Sponges lack the characteristic *nettle-organs* which all Sea-nettles possess.

The common primary form of all Zoophytes must be looked for in the *Protæscus*, an animal form long since extinct, but whose existence is proved according to the biogenetic principle by the Ascula. This Ascula is an ontogenetical development form which, in Sponges as well

as in Sea-nettles, proceeds from the Gastrula. (Compare the Ascula of the calcareous sponge on the Frontispiece, Fig 7, 8.) For after the Gastrula of zoophytes has for a time swum about in the water it sinks to the bottom, and there adheres by that pole of its axis which is opposite to the opening of the mouth. The external cells of the ectoderm draw in their vibrating, ciliary hairs, whereas, on the contrary, the inner cells of the entoderm begin to form them. Thus the Ascula, as we call this changed form of larva, is a simple sack, its cavity (the cavity of the stomach or intestine) opening by a mouth externally, at the upper pole of the longitudinal axis (opposite the basal point of fixture). The entire body is here in a certain sense a mere stomach or intestinal canal, as in the case of the Gastrula. The wall of the sack, which is both body wall and intestinal wall, consists of two layers or coats of cells, a fringed *entoderm*, or gastral layer (corresponding with the inner or vegetative germ-layer of the higher animals), and an unfringed exoderm or dermal layer (corresponding with the external or animal germ-layer of the higher animals). The original *Protascus*, a true likeness of which is still furnished by the Ascula, probably formed egg-cells and sperm-cells out of its gastral layer.

The Protascads—as we will call the most ancient group of vegetable animals, represented by the Protascus-type—divided into two lines or branches, the Spongiæ and the Sea-nettles, or Acalephæ. I have shown in my Monograph of the Calcareous Sponges (vol. i. p. 485) how closely these two main classes of Zoophytes are related, and how they must both be derived, as two diverging forms, from the Protascus-form. The primary form of Spongiæ, which I

have there called Archispongia, arose out of the Protascus by the formation of pores through its body-wall; the primary form of Sea-nettles, which I there called Archydra, developed out of the Protascus by the formation of nettle-organs, as also by the formation of feelers or tentacles.

The main-class or branch of the *Sponges*, *Spongiæ*, or *Porifera*, lives in the sea, with the single exception of the green fresh-water Sponge (*Spongilla*). These animals were long considered as plants, later as Protista; in most Manuals they are still classed among the primæval animals, or Protozoa. But since I have demonstrated their development out of the Gastrula, and the construction of their bodies of two cellular germ-layers (as in all higher animals), their close relationship to Sea-nettles, and especially to the Hydrapolyps, seems finally to be established. The *Olynthus* especially, which I consider as the common primary form of calcareous sponges, has thrown a complete and unmistakable light upon this point.

The numerous forms comprised in the class of *Spongiæ* have as yet been but little examined; they may be divided into three legions and eight orders. The first legion consists of the soft, gelatinous *Mucous Sponges* (*Myxospongiæ*), which are characterized by the absence of any hard skeleton. Among them are, on the one hand, the long-since-extinct primary forms of the whole class, the type of which I consider to be the Archispongia; on the other hand there are the still living, gelatinous sponges, of which the *Halisarca* is best known. We can obtain a notion of the Archispongia, the most ancient primæval sponge, if we imagine the *Olynthus* (see Frontispiece), to be deprived of its radiating calcareous spiculæ.

The second legion of Spongiæ contains the *Fibrous Sponges* (Fibrospongiæ), the soft body of which is supported by a firm, fibrous skeleton. This fibrous skeleton often consists merely of so-called "horny fibres," formed of a very elastic, not readily destructible, organic substance. This is the case for instance in our common bathing Sponge (*Euspongia officinalis*), the purified skeleton of which we use every morning when washing. Blended with the horny, fibrous skeleton of many of these Sponges, there are numerous flinty spicula; this is the case for example with the fresh-water Sponge (*Spongilla*). In others the whole skeleton consists of only calcareous or silicious spicula which are frequently interwoven into an extremely beautiful lattice-work, as in the celebrated Venus' Flower Basket (*Euplectella*). Three orders of fibrous sponges may be distinguished according to the different formation of the spicula, namely, Chalynthina, Geodina, and Hexactinella. The natural history of the fibrous sponges is of especial interest to the Theory of Descent, as was first shown by Oscar Schmidt, the greatest authority on this group of animals. In no other group, perhaps, can the unlimited pliability of the specific form, and its relation to Adaptation and Inheritance, be so clearly followed step by step; perhaps in no other group is the species so difficult to limit and define.

This proposition, which applies to the great legion of the Fibrous Sponges, applies in a still higher degree to the smaller but exceedingly interesting legion of the calcareous sponges (*Calcispongiæ*), on which in 1872, after five years' careful examination, I published a comprehensive Monograph. The sixty plates of figures accompanying this Monograph explain the extreme pliability of these small sponges,





“good species” of which, in fact, cannot be spoken of in the usual systematic sense. We find among them only varying series of forms, which do not even completely transmit their specific form to their nearest descendants, but by adaptation to subordinate, external conditions of existence, perpetually change. It frequently occurs here, that there arise out of one and the same stock different form-species, which according to the usual system would belong to several quite distinct genera; this is the case, for instance, with the remarkable *Ascometra* (Frontispiece, Fig. 10.) The entire external bodily form is much more pliable and protean in Calcareous Sponges than in the silicious sponges, which are characterized by possessing silicious spicula, forming a beautiful skeleton. Through the study of the comparative anatomy and ontogeny of calcareous sponges, we can recognise, with the greatest certainty, the common primary form of the whole group, namely, the sack-shaped *Olynthus*, whose development is represented in the Frontispiece (compare its explanation in the Appendix). Out of the *Olynthus* (Fig. 9 on the Frontispiece), the order of the *Ascones* was the first to develop, out of which, at a later period, the two other orders of Calcareous Sponges, the *Leucones* and *Sycones*, arose as diverging branches. Within these orders, the descent of the individual forms can again be followed step by step. Thus the Calcareous Sponges in every respect confirm the proposition which I have elsewhere maintained: that “the natural history of sponges forms a connected and striking argument in favour of Darwin.”

The second main class or branch in the tribe of Zoophytes is formed by the Sea-nettles (*Acalephæ*, or *Cnidæ*). This interesting group of animals, so rich in forms, is composed

of three different classes, namely, the Hood-jellies (Hydromedusæ), the Comb-jellies (Ctenophora), and the Corals (Coralla). The hypothetical, extinct Archydra must be looked upon as the common primary form of the whole group; it has left two near relations in the still living fresh-water polyps (Hydra and Cordylophora). The Archydra was very closely related to the simplest forms of Spongiæ (Archispongia and Olynthus), and probably differed from them only by possessing nettle organs, and by the absence of cutaneous pores. Out of the Archydra there first developed the different Hydroid polyps, some of which became the primary forms of Corals, others the primary forms of Hydromedusæ. The Ctenophora developed later out of a branch of the latter.

The Sea-nettles differ from the Spongiæ (with which they agree in the characteristic formation of the system of the alimentary canal) principally by the constant possession of nettle organs. These are small bladders filled with poison, large numbers—generally millions—of which are dispersed over the skin of the sea nettles, and which burst and empty their contents when touched. Small animals are killed by this; in larger animals this nettle poison causes a slight inflammation of the skin, just as does the poison of our common nettles. Any one who has often bathed in the sea, will probably have at times come in contact with large Hood-jellies (Jelly-fish), and become acquainted with the unpleasant burning feeling which their nettle organs can produce. The poison in the splendid blue Jelly-fish, Physalia, or Portuguese Man-of-war, acts so powerfully that it may lead to the death of a human being.

The class of Corals (Coralla) lives exclusively in the sea,

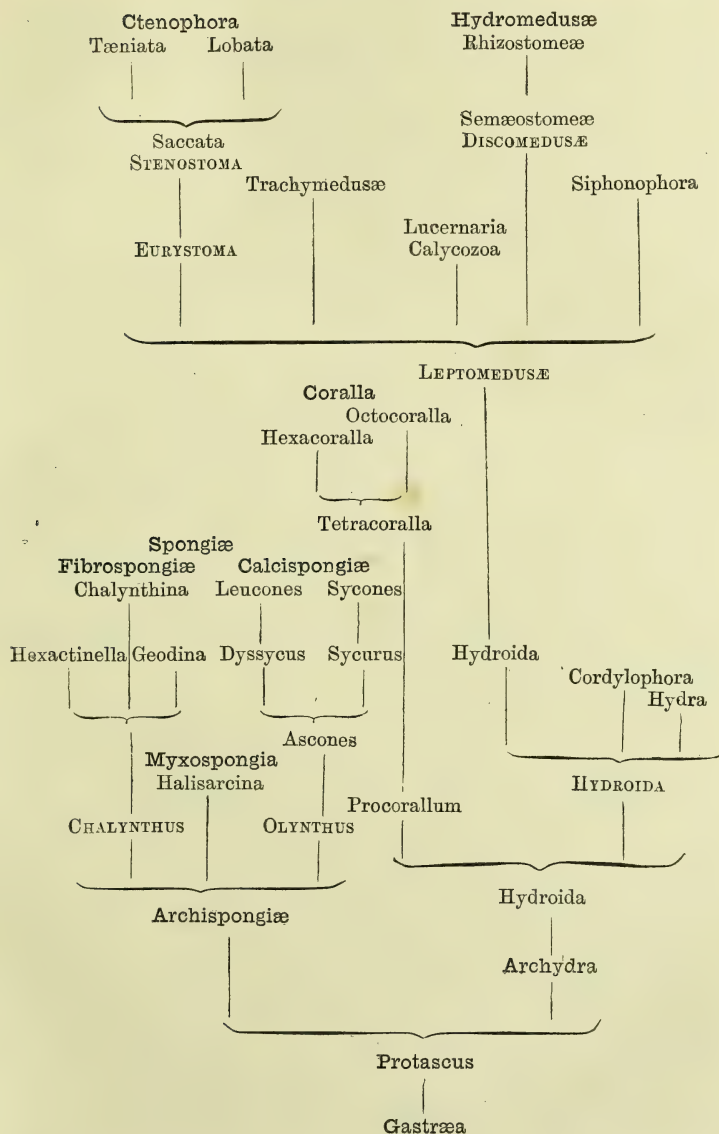
and is more especially represented in the warm seas by an abundance of beautiful and highly-coloured forms like flowers. Hence they are also called *Flower-animals* (Anthozoa). Most of them are attached to the bottom of the sea, and contain an internal calcareous skeleton. Many of them by continued growth produce such immense stocks that their calcareous skeletons have formed the foundation of whole islands, as is the case with the celebrated coral reefs and atolls of the South Seas, the remarkable forms of which were first explained by Darwin.¹³ In corals the counterparts, or antimera—that is, the corresponding divisions of the body which radiate from and surround the central main axis of the body—exist sometimes to the number of four, sometimes to the number of six or eight. According to this we distinguish three legions, the Fourfold (Tetracoralla), Sixfold (Hexacoralla), and Eightfold corals (Octocoralla). The fourfold corals form the common primary group of the class, out of which the sixfold and eightfold have developed as two diverging branches.

The second class of Sea-nettles is formed by the *Hood-jellies* (Medusæ) or *Polyp-jellies* (Hydromedusæ). While most corals form stocks like plants, and are attached to the bottom of the sea, the Hood-jellies generally swim about freely in the form of gelatinous bells. There are, however, numbers of them, especially the lower forms, which adhere to the bottom of the sea, and resemble pretty little trees. The lowest and simplest members of this class are the little fresh-water polyps (Hydra and Cordylophora). We may look upon them as but little changed descendants of those *Primæval polyps* (Archydræ), from which, during the primordial period, the whole division of the Sea-nettles

SYSTEMATIC SURVEY

Of the 4 Classes and 30 Orders of the Animal Plants, or Zoophytes.

<i>Classes of the Zoophytes.</i>	<i>Legions of the Zoophytes.</i>	<i>Orders of the Zoophytes.</i>	<i>A Genus Name as example.</i>
I. Sponges Spongiæ or Porifera	I. Myxospongiæ <i>Mucous Sponges</i>	{ 1. Archispongina 2. Halisarcina	Archispongia Halisarca
	II. Fibrospongiæ <i>Fibrous Sponges</i>	{ 3. Chalynthina 4. Geodina 5. Hexactinella	Spongilla Ancorina Euplectella
	III. Calcispongiæ <i>Calcareous Sponges</i>	{ 6. Ascones 7. Leucones 8. Sycones	Olynthus Dyssycus Sycurus
II. Corals Coralla or Anthozoa	IV. Tetracoralla <i>Fourfold Corals</i>	{ 9. Rugosa 10. Paranemeta	Cyathophyllum Cereanthus
	V. Hexacoralla <i>Sixfold Corals</i>	{ 11. Cauliculata 12. Madreporaria 13. Halirhoda	Antipathes Astræa Actinia
	VI. Octacoralla <i>Eightfold Corals</i>	{ 14. Alcyonida 15. Gorgonida 16. Pennatulida	Lobularia Isis Veretillum
III. Jelly-polyps Hydromedusæ or Hood-jellies Medusa	VII. Archydræ <i>Primæval Polyps</i>	{ 17. Hydraria	Hydra
	VIII. Leptomedusæ <i>Soft Jelly-fish</i>	{ 18. Vesiculata 19. Ocellata 20. Siphonophora	Sertularia Tubularia Physophora
	IX. Trachymedusæ <i>Hard Jelly-fish</i>	{ 21. Marsiporchida 22. Phyllorchida 23. Elasmorchida	Trachynema Geryonia Charybdæ
	X. Calycozoa <i>Stalked Jellies</i>	{ 24. Podactinaria	Lucernaria
	XI. Discomedusæ <i>Disc-jellies</i>	{ 25. Semæostomeæ 26. Rhizostomeæ	Aurelia Crambessa
IV. Comb-jellies Ctenophora	XII. Eurystoma <i>Wide-mouthed</i>	{ 27. Beroidea	Beroë
	XIII. Stenostoma <i>Narrow-mouthed</i>	{ 28. Saccata 29. Lobata 30. Tæniata	Cytippe Eucharis Cestum



originated. Scarcely distinguishable from the Hydra are the adherent Hydroid polyps (Campanularia, Tubularia), which produce freely swimming medusæ by budding, and out of the eggs of these there again arise adherent polyps. These freely swimming Hood-jellies are mostly of the form of a mushroom, or of an umbrella, from the rim of which many long and delicate tentacles hang. They are among the most beautiful and most interesting inhabitants of the sea. The remarkable history of their lives, and especially the complicated alternation of generation of polyps and medusæ, are among the strongest proofs of the truth of the theory of descent. For just as Medusæ still daily arise out of the Hydroids, did the freely swimming medusa-form originally proceed, phylogenetically, out of the adherent polyp-form. Equally important for the theory of descent is the remarkable *division of labour* of the individuals, which among some of them is developed to an astonishingly high degree, more especially in the splendid *Siphonophora*.³⁷ (Plate VII. Fig. 13).

The third class of Sea-nettles—the peculiar division of Comb-jellies (Ctenophora), probably developed out of a branch of the Hood-jellies. The Ctenophora, which are also called Ribbed-jellies, possess a body of the form of a cucumber, which, like the body of most Hood-jellies, is as clear and transparent as crystal or cut glass. Comb or Ribbed-jellies are characterized by their peculiar organs of motion, namely, by eight rows of paddling, ciliated leaflets, which run in the form of eight ribs from one end of the longitudinal axis (from the mouth) to the opposite end. Those with narrow mouths (Stenostoma) probably developed later out of those with wide mouths (Eurystoma). (Compare Plate VII. Fig. 16.)

The third tribe of the animal kingdom, the phylum of *Worms* or worm-like animals (Vermes, or Helminthes), contains a number of diverging branches. Some of these numerous branches have developed into well-marked and perfectly independent classes of Worms, but others changed long since into the original, radical forms of the four higher tribes of animals. Each of these four higher tribes (and likewise the tribe of Zoophytes) we may picture to ourselves in the form of a lofty tree, whose branches represent the different classes, orders, families, etc. The phylum of Worms, on the other hand, we have to conceive as a low bush or shrub, out of whose root a mass of independent branches shoot up in different directions. From this densely branched shrub, most of the branches of which are dead, there rise four high stems with many branches. These are the four lofty trees just mentioned as representing the higher phyla—the Echinoderma, Articulata, Mollusca, and Vertebrata. These four stems are directly connected with one another at the root only, to wit, by the common primary group of the Worm tribe.

The extraordinary difficulties which the systematic arrangement of Worms presents, for this reason merely, are still more increased by the fact that we do not possess any fossil remains of them. Most of the Worms had and still have such soft bodies that they could not leave any characteristic traces in the neptunic strata of the earth. Hence in this case again we are entirely confined to the records of creation furnished by ontogeny and comparative anatomy. In making then the exceedingly difficult attempt to throw a few hypothetical rays of light upon the obscurity of the pedigree of Worms, I must therefore

expressly remark that this sketch, like all similar attempts, possesses only a provisional value.

The numerous classes distinguished in the tribe of Worms, and which almost every zoologist groups and defines according to his own personal views, are, in the first place, divided into two essentially different groups or branches, which in my Monograph of the Calcareous Sponges I have termed *Acœlomi* and *Cœlomati*. For all the lower Worms which are comprised in the class of Flat-worms (*Platyhelminthes*), (the Gliding-worms, Sucker-worms, Tape-worms), differ very strikingly from other Worms, in the fact that they possess neither blood nor body-cavity (no *cœlome*) ; they are, therefore, called *Acœlomi*. The true cavity, or *cœlome*, is completely absent in them as in all the Zoophytes ; in this important respect the two groups are directly allied. But *all other Worms* (like the four higher tribes of animals) possess a genuine body-cavity and a vascular system connected with it, which is filled with blood ; hence we class them together as *Cœlomati*.

The main division of *Bloodless Worms* (*Acœlomi*) contains, according to our phylogenetic views, besides the still living Flat-worms, the unknown and extinct primary forms of the whole tribe of Worms, which we shall call the *Primæval Worms* (*Archelminthes*). The type of these *Primæval Worms*, the ancient *Prothelmis*, may be directly derived from the *Gastræa* (p. 133). Even at present the *Gastrula*-form — the faithful historical portrait of the *Gastræa*—recurs in the ontogenesis of the most different kinds of worms as a transient larva-form. The ciliated Gliding-worms (*Turbellaria*), the primary group of the present Planary or Flat-worms (*Platyhelminthes*), are the

nearest akin to the Primæval Worms. The parasitical Sucker-worms (Trematoda) arose out of the Gliding-worms, which live freely in water, by adaptation to a parasitical mode of life; and out of them later on—by an increasing parasitism—arose the Tape-worms (Cestoda).

Out of a branch of the Acœlomi arose the second main division of the Worm tribe, the Worms with blood and body-cavity (Coelomati): of these there are seven different classes.

The Pedigree on p. 151 shows how the obscure phylogeny of the seven classes of Coelomati may be supposed to stand. We shall, however, mention these classes here quite briefly, as their relationships and derivation are, at present, still very complicated and obscure. More numerous and more accurate investigations of the ontogeny of the different Coelomati will at some future time throw light upon their phylogenesis.

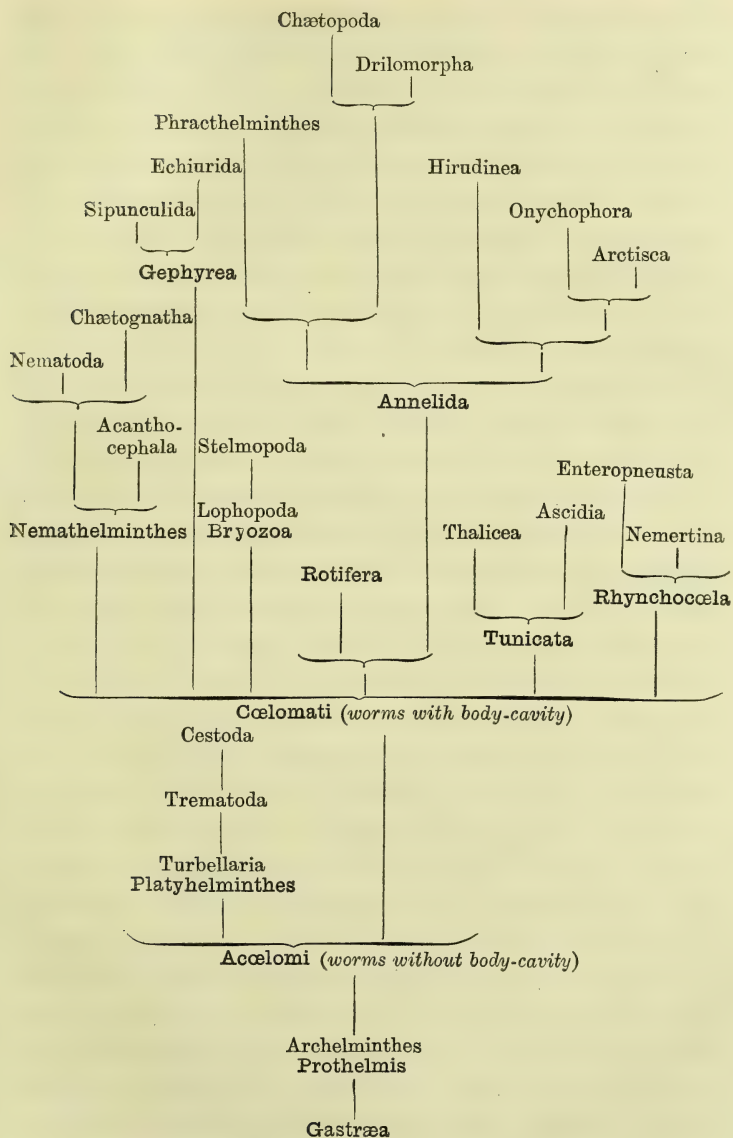
The Round Worms (Nemathelminthes) which we mention as the first class of the Coelomati, and which are characterized by their cylindrical form, consist principally of parasitical Worms which live in the interior of other animals. Of human parasites, the celebrated *Trichinæ*, the Maw-worms, Whip-worms, etc., for example, belong to them. The Star-worms (Gephyrea) which live exclusively in the sea are allied to round worms, and the comprehensive class of Ring-worms (Annelida) are allied to the former. To the Ring-worms, whose long body is composed of a number of segments, all alike in structure, belong the Leeches (Hirudinea), Earth-worms (Lumbricina), and all the marine bristle-footed Worms (Chætopoda). Nearly akin to them are the Snout-worms (Rhynchocœla), and the small microscopic Wheel-

SYSTEMATIC SURVEY

Of the 8 Classes and 22 Orders of the Worm Tribe.

(Compare Gen. Morph. II. Plate V. pp. 75-77.)

<i>Classes of the Worm Tribe.</i>	<i>Orders of the Worm Tribe.</i>	<i>Systematic Name of the Orders of Worms.</i>	<i>Name of a Genus as example.</i>
1. <i>Flat Worms</i> Platyhel- minthes	1. Primæval worms 2. Gliding-worms 3. Sucker-worms 4. Tape-worms	1. Archelminthes 2. Turbellaria 3. Trematoda 4. Cestoda	Prothelmis Planaria Distoma Tænia
2. <i>Round Worms</i> Nemathel- minthes	5. Arrow-worms 6. Thread-worms 7. Hook-headed worms	5. Chætognatha 6. Nematoda 7. Acanthocephala	Sagitta Trichina Echinorhynchus
3. <i>Moss Polyps</i> Bryozoa	8. Horse-shoe-lipped 9. Circle-lipped	8. Lophopoda 9. Stelmopoda	Alcyonella Retepora
4. <i>Sea-sacs</i> Tunicata	10. Sea-squirts 11. Sea-barrels	10. Ascidia 11. Thaliacea	Phallusia Salpa
5. <i>Probos- cideans</i> Rhyncho- cœla	12. Tongue-worms 13. Cord-worms	12. Enteropneusta 13. Nemertina	Balanoglossus Borlasia
6. <i>Star- Worms</i> Gephyrea	14. Star-worms with- out bristles 15. Star-worms with bristles	14. Sipunculida 15. Echiurida	Sipunculus Echiurus
7. <i>Wheel Animalcule</i> Rotifera	16. Wheel-worms	16. Rotatoria	Hydatina
8. <i>Ring Worms</i> Annelida	17. Bear-worms 18. Worms with claws 19. Leeches 20. Land-worms 21. Mailed worms 22. Bristle-footed worms	17. Arctisca 18. Onychophora 19. Hirudinea 20. Drilomorpha 21. Phracthelminthes 22. Chætopoda	Macrobiotus Peripatus Hirudo Lumbricus Crossopodia Aphrodite



worms (Rotifera). The unknown, extinct, primary forms of the tribe of Sea-stars (Echinoderma), and of the tribe of the articulated animals (Arthropoda), were nearest akin to the Ring-worms. On the other hand, we must probably look for the primary forms of the great tribe of Molluscs in extinct Worms, which were very closely related to the Moss-polyps (Bryozoa) of the present day; and for the primary forms of the Vertebrata in the unknown Cœlomati, whose nearest kin of the present day are the Sea-sacs, especially the Ascidia.

The class of Sea-sacs (Tunicata) is one of the most remarkable among Worms. They all live in the ocean, where some of the Ascidiaë adhere to the bottom, while others (the sea-barrels, or Thaliacea) swim about freely. In all of them the non-jointed body has the form of a simple barrel-shaped sack, which is surrounded by a thick cartilaginous mantle. This mantle consists of the same non-nitrogenous combination of carbon, which, under the name of cellulose, plays an important part in the Vegetable Kingdom, and forms the largest portion of vegetable cellular membranes, and consequently also the greater part of wood. The barrel-shaped body generally possesses no external appendages. No one would recognise in them a trace of relationship to the highly differentiated vertebrate animals. And yet this can no longer be doubted, since Kowalewsky's investigations, which in the year 1867 suddenly threw an exceedingly surprising and unmistakable light upon them. From these investigations it has become clear that the individual development of the adherent simple Ascidian Phallusia agrees in most points with that of the lowest vertebrate animal, namely, the Lancelet (*Amphioxus lanceolatus*).

The early stages of the *Ascidia* possess the beginnings of the *spinal marrow* and the *spinal column* (*chorda dorsalis*) lying beneath it, which are the two most essential and most characteristic organs of the vertebrate animal. Accordingly, of all invertebrate animals known to us, the *Tunicates* are *without doubt the nearest blood relations of the Vertebrates*, and must be considered as the nearest relations of those Worms out of which the vertebrate tribe has developed. (Compare Plates XII. and XIII.)

While thus different branches of the Cœlomatous group of the Worms furnish us with several genealogical links leading to the four higher tribes of animals, and give us important phylogenetic indications of their origin, the lower group of *Acœlomi*, on the other hand, show close relationships to the Zoophytes, and to the Primæval animals. The great phylogenetic interest of the Worm tribe rests upon this peculiar intermediate position.

CHAPTER XIX.

PEDIGREE AND HISTORY OF THE ANIMAL KINGDOM.

II. MOLLUSCA, STAR-FISHES, AND ARTICULATED ANIMALS.

Tribe of Molluscs.—Four Classes of Molluscs: Lamp-shells (Spirobranchia); Mussels (Lamellibranchia); Snails (Cochlides); Cuttle-fish (Cephalopoda).—Tribe of Star-fishes, or Echinoderma.—Their Derivation from Ringed Worms (Mailed Worms, or Phræthelminthes).—The Alternation of Generation in the Echinoderma.—Four Classes of Star-fish: Sea-stars (Asteridea); Sea-lilies (Crinoidea); Sea-urchins (Echinidea); Sea-cucumbers (Holothuridea).—Tribe of Articulated Animals, or Arthropoda.—Four Classes of Articulated Animals: Branchiata, or Crustacea, breathing through gills; Jointed Crabs; Mailed Crabs; Articulata Tracheata, breathing through Air Tubes. Spiders (Long Spiders, Round Spiders).—Myriopods.—Insects.—Chewing and Sucking Insects.—Pedigree and History of the Eight Orders of Insects.

THE great natural main groups of the animal kingdom, which we have distinguished as TRIBES, or PHYLA ("types" according to Bär and Cuvier), are not all of equal systematic importance for our phylogeny or history of the pedigree of the living world. They can neither be classed in a single series of stages, one above another, nor be considered as entirely independent stems, nor as equal branches of a single family-tree. It seems rather (as we saw in the last chapter) that the tribe of Protozoa, the so-called primæval animals, is the common radical group of the whole animal kingdom. Out of the Gastræada—which we class among

the Protozoa—the Zoophytes and the Worms have developed, as two diverging branches. We must now in turn look upon the varied and much-branching tribe of Worms as the common primary group, out of which (from perfectly distinct branches) arose the remaining tribes, the four higher phyla of the animal kingdom. (Compare the Pedigree, p. 133.)

Let us now take a genealogical look at these four higher tribes of animals, and try whether we cannot make out the most important outlines of their pedigree. Even should this attempt prove defective and imperfect, we shall at all events have made a beginning, and paved the road for subsequent and more satisfactory attempts.

It does not matter in what succession we take up the examination of the four higher tribes. For these four phyla have no close relationship whatever among one another, but have grown out from entirely distinct branches of the group of Worms (p. 133). We may consider the tribe of Molluscs as the most imperfect and the lowest in point of morphological development. We nowhere meet among them with the characteristic articulation or segmented formation of the body, which distinguishes even the Ring-worms, and which in the other three higher tribes—the Echinoderma, Articulata, and Vertebrata—is most essentially connected with the high development of their forms, their differentiation, and perfection. The body in all Molluscs—in mussels, snails, etc.—is a simple non-jointed sack, in the cavity of which lie the intestines. The nervous system consists not of a cord but of several distinct (generally three) pairs of knots loosely connected with one another. For these and many other anatomical reasons, I consider the tribe of Molluscs (in spite of the high physiological development of its most

perfect forms) to be morphologically the lowest among the four higher tribes of animals.

Whilst, for reasons already given, we exclude the Moss-polyps, and Tunicates—which have hitherto been generally classed with the tribe of Molluscs—we retain as genuine Molluscs the following four classes: Lamp-shells, Mussels, Snails, and Cuttles. The two lower classes of Molluscs, the Lamp-shells and Mussels, possess neither head nor teeth, and they can therefore be comprised under one main class, or branch, as headless animals (*Acephala*), or toothless animals (*Anodontoda*). This branch is also frequently called that of the clam-shells (*Conchifera*, or *Bivalvia*), because all its members possess a two-valved calcareous shell. In contrast to these the two higher classes of Molluscs, the snails and cuttles, may be represented as a second branch with the name of Head-bearers (*Cephalophora*), or Tooth-bearers (*Odontophora*), because both head and teeth are developed in them.

The soft, sack-shaped body in most Molluscs is protected by a calcareous shell or house, which in the *Acephala* (lamp-shells and mussels) consists of two valves, but in the *Cephalophora* (snails and cuttles) is generally a spiral tube (the so-called snail's house). Although these hard skeletons are found in large quantities in a petrified state in all the neptunic strata, yet they tell us but little of the historical development of the tribe, which must have taken place for the most part in the primordial period. Even in the Silurian strata we find fossil remains of all the four classes of Molluscs, one beside the other, and this, conjointly with much other evidence, distinctly proves that the tribe of Molluscs had then obtained a strong development, when the higher tribes, especially the

Articulates and Vertebrates, had scarcely got beyond the beginning of their historical development. In subsequent periods, especially in the primary and secondary periods, these higher tribes increased in importance more and more at the expense of Molluscs and Worms, which were no match for them in the struggle for life, and accordingly decreased in number. The still living Molluscs and Worms must be considered as only a proportionately small remnant of the vast molluscan fauna, which greatly predominated in the primordial and primary periods over the other tribes. (Compare Plate VI. and explanation in the Appendix.)

No tribe of animals shows more distinctly than do the Molluscs, how very different the value of fossils is in geology and in phylogeny. In geology the different species of the fossil shells of Molluscs are of the greatest importance, because they serve as excellent marks whereby to characterize the different groups of strata, and to fix their relative ages. As far as relates to the genealogy of Molluscs, however, they are of very little value, because, on the one hand, the shells are parts of quite subordinate morphological importance, and because the actual development of the tribe belongs to the earlier primordial period, from which no distinct fossils have been preserved. If therefore we wish to construct the pedigree of Molluscs, we are mainly dependent upon the records of ontogeny and comparative anatomy from which we obtain something like the following result. (Gen. Morph. ii. Plate VI. pp. 102-116.)

The lowest stage of the four classes of genuine Molluscs known to us, is occupied by the Lamp-shells or Spiral-gills (Spirobranchia), frequently but inappropriately called Arm-footers (Brachiopoda), which have become attached to the

bottom of the sea. There now exist but few forms of this class; for instance, some species of *Lingula*, *Terebratula*, and others akin to them, which are but feeble remnants of the great variety of forms which represented the Lamp-shells in earlier periods of the earth's history. In the Silurian period they constituted the principal portion of the whole Mollusc tribe. From the agreement which, in many respects, their early stage of development presents with the Moss animals, it has been concluded that they have developed out of Worms, which were nearly related to this class. Of the two sub-classes of Lamp-shells, the Hinge-less (*Ecardines*) must be looked upon as the lower and more imperfect, the Hinged (*Testicardines*) as the higher and more fully developed group.

The anatomical difference between the Lamp-shells and the three other classes of Molluscs is so considerable that the latter may be distinguished from the former by the name of *Otocardia*. All the *Otocardia* have a heart with chamber (ventricle) and ante-chamber (auricle), whereas Lamp-shells do not possess the ante-chamber. Moreover, the central nervous system is developed only in the former (and not in the latter) in the shape of a complete pharyngeal ring. Hence the four classes of Molluscs may be grouped in the following manner :—

I. Molluscs without head. <i>Acephala</i> .	{	1. Lamp-shells (<i>Spirobranchia</i>).	{	I. Haplocardia (with simple heart).
		2. Mussels (<i>Lamellibranchia</i>).		
II. Molluscs with head. <i>Cephalophora</i> .	{	3. Snails (<i>Cochlides</i>).	{	II. Otocardia (with chamber and ante-chamber to the heart).
		4. Cuttles (<i>Cephalopoda</i>).		

The result of these structural dispositions for the history of the pedigree of Molluscs, which is confirmed by palæontology, is that Lamp-shells stand much nearer to the primæval root of the whole tribe of Molluscs than do the Otocardia. Probably Mussels and Snails developed as two diverging branches out of Molluscs, which were nearly akin to the Lamp-shells.

Mussels, or Plate-gills (*Lamellibranchia*), possess a bivalved shell like the Lamp-shells. In the latter, one of the two valves covers the back, the other the belly of the animal; whereas in Mussels the two valves lie symmetrically on the right and left side of the body. Most Mussels live in the sea, only a few in fresh water. The class is divided into two sub-classes, *Asiphonia* and *Siphonida*, of which the latter were developed at a later period out of the former. Among the *Asiphonia* are Oysters, mother-of-pearl Shells, and fresh water Mussels; among the *Siphonida*, which are characterized by a respiratory tube, are the Venus-shells, Razor-shells, and Burrowing Clams. The higher Molluscs seem to have developed at a later period out of those without head and teeth; they are distinguished from the latter by the distinct formation of the head, and more especially by a peculiar kind of tooth apparatus. Their tongue presents a curious plate, armed with a great number of teeth. In our common Vineyard Snail (*Helix pomatia*) the number of teeth amount to 21,000, and in the large Garden Slug (*Limax maximus*) to 26,800.

We distinguish two sub-classes among the Snails (*Cochlides*, or *Gasteropoda*), namely, the Stump-headed and the Large-headed Snails. The Stump-headed Snails (*Perocephala*) are very closely allied to Mussels (through the Tooth-shells),

SYSTEMATIC SURVEY

Of the 4 Classes, 8 Sub-classes, and 21 Orders of Molluscs.

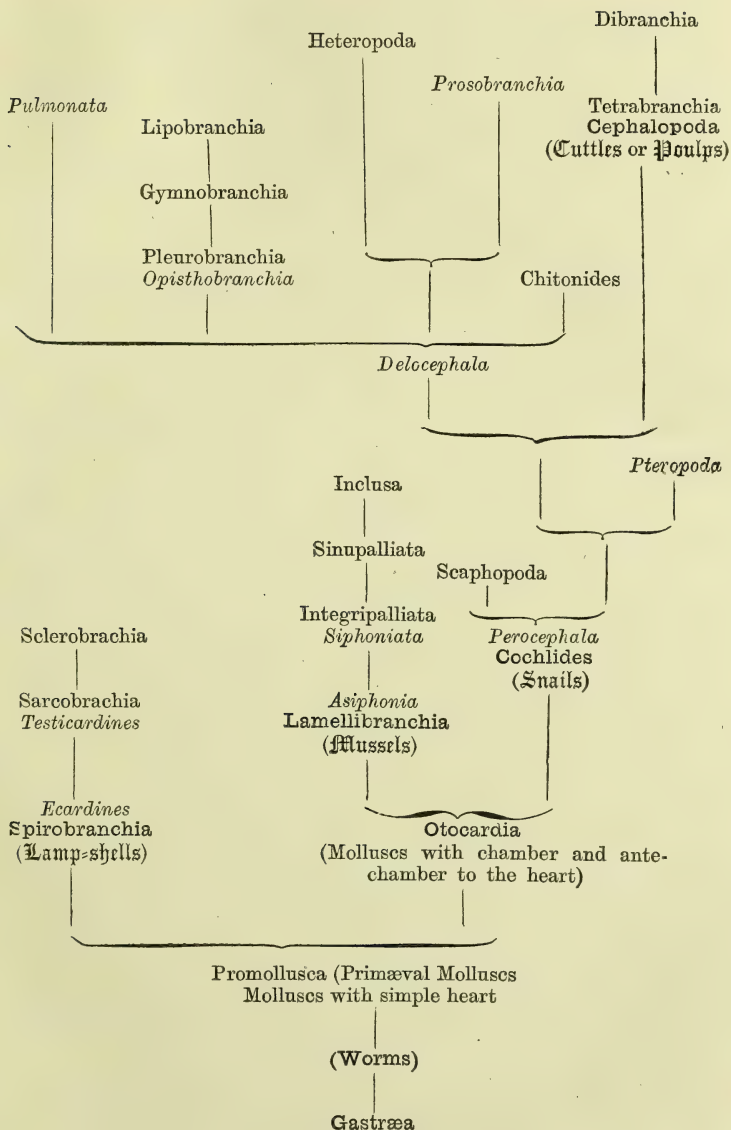
<i>Classes of Molluscs.</i>	<i>Sub-classes of Molluscs.</i>	<i>Orders of Molluscs.</i>	<i>Systematic Name of the Orders.</i>
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I. Molluscs without head or teeth: ACEPHALA or ANODONTODA.

I. Lamp-shells Spirobranchia or Brachiopoda	I. Ecardines <i>Hinge-less</i>	{ 1. Stalked 2. Flattened	1. Lingulida 2. Craniada
	II. Testicardines <i>Hinge-less</i>	{ 3. Fleshy-armed 4. Calcareous-armed	3. Sarcobranchia 4. Sclerobranchia
II. Mussels or Plate-gills Lamellibranchia or Phyllobranchia	III. Asiphonia <i>Mussels without respiratory tubes</i>	{ 5. One-muscle 6. Uneven-muscle 7. Even-muscle	5. Monomya 6. Heteromya 7. Isomya
	IV. Siphonida <i>Mussels with respiratory tubes</i>	{ 8. Round-mantled 9. Bay-mantled 10. Tube-mussels	8. Integripallata 9. Sinupallata 10. Inclusa

II. Molluscs with head and teeth: CEPHALOPHORA or ODONTOPHORA.

III. Snails Cochlides or Gasteropoda	V. Stump-headed <i>Perocephala</i>	{ 11. Tube-snails 12. Butterfly-snails	11. Scaphopoda 12. Pteropoda
	VI. Large-headed <i>Deinocephala</i>	{ 13. With hind gills 14. With fore gills 15. Swimming-snails 16. Beetle-snails 17. Snails with lungs	13. Opisthobranchia 14. Prosobranchia 15. Heteropoda 16. Chitonoida 17. Pulmonata
IV. Cuttles or Poullps Cephalopoda	VII. Chamber-Poullps with four gills <i>Tetrabranchia</i>	{ 18. Pearl boats 19. Ammon's horns	18. Nautilida 19. Ammonitida
	VIII. Ink-Poullps with two gills <i>Dibranchia</i>	{ 20. Ten-armed 21. Eight-armed	20. Decabrachiones 21. Octobrachiones



and also to the Cuttle-fish (through the Butterfly-snails). The more highly developed Snails, with large heads (Delocephala), can be divided into Snails with gills (Branchiata) and Snails with lungs (Pulmonata). Among the latter are the Land-snails, the only Molluscs which have left the water and become habituated to a life on land. The great majority of Snails live in the sea, only a few live in fresh water. Some River-snails in the tropics (the Ampullaria) are amphibious, living sometimes on land, sometimes in water, and at one time they breathe through gills, at another through lungs. They have both kinds of respiratory organs, like the Mud-fish and Gilled Newts among the Vertebrata.

The fourth and last class, and at the same time the most highly developed class of Molluscs, is that of the Cuttles, or Poulps, also called Cephalopoda (foot attached to the head). They all live in the sea, and are distinguished from Snails by eight, ten, or more long arms, which surround the mouth in a circle. The Cuttles existing in our recent oceans—the Sepia, Calamary, Argonaut, and Pearly Nautilus—are, like the few Spiral-gill Lamp-shells of the present time, but a poor remnant of the host which represents this class in the oceans of the primordial, primary, and secondary periods. The numerous fossil “Ammon’s horns” (Ammonites), “pearl boats” (Nautilus), and “thunderbolts” (Belemnites) are evidences of the long since extinct splendour of the tribe. The Poulps, or Cuttles, have probably developed out of a low branch of the snail class, out of the Butterfly-snails (Pteropoda) or kindred forms.

The different sub-classes and orders, distinguished in the four classes of Molluscs, whose systematic succession is

given on the Table (p. 160), furnish various proofs of the validity of the law of progress by their historical development and by the systematic development corresponding to it. As however these subordinate groups of Molluscs are in themselves of no further special interest, I must refer to the sketch of their pedigree on p. 161, and to the detailed pedigree of Molluscs which I have given in my General Morphology, and I shall now at once turn to the consideration of the tribe of Star-fishes.

The Star-fishes (*Echinoderma*, or *Estrellæ*) among which are the four classes of Sea-stars, Sea-lilies, Sea-urchins, and Sea-cucumbers are one of the most interesting divisions of the animal kingdom, and yet we know less about them than about any. They all live in the sea. Every one who has been at the sea shore must have seen at least two of their forms, the Sea-stars and the Sea-urchins. The tribe of Star-fishes must be considered as a completely independent tribe of the animal kingdom on account of its very peculiar organization, and must be carefully distinguished from the Animal-plants—*Zoophytes*, or *Cœlenterata*, with which it is still frequently but erroneously classed under the name *Radiata* (as for example, by Agassiz, who even to this day defends this error of Cuvier's, together with many others).

All *Echinoderma* are characterized, and at the same time distinguished from all other animals, by a very remarkable apparatus for locomotion, which consists of a complicated system of canals or tubes, filled with sea water from without. The sea water in these aqueducts is moved partly by the strokes of the cilia, or vibratile hairs lining their walls, and partly by the contractions of the muscular walls of the tubes themselves, which resemble india-rubber bags.

The water is pressed from the tubes into a number of little hollow feet, which thereby become widely distended, and are then employed for walking and suction. The Sea-stars are moreover characterized by a peculiar calcareous formation in the skin, which in most cases forms a firm, well-closed coat of mail, composed of a number of plates. In almost all Echinoderma the body consists of five radii (counterparts, or antimera) standing round the main axis of the body, where they meet. It is only in some species of Sea-stars that the number of these radii amount to more than five—to 6—9, 10—12, or even to 20—40; and in this case the number of radii is generally not constant, but varies in different individuals of one species.

The historical development and the pedigree of the Echinoderma are completely revealed to us by their numerous and, in most cases, excellently preserved fossil remains, by their very remarkable individual developmental history, and by their interesting comparative anatomy; this is the case with no other tribe of animals, even the Vertebrata themselves are not to be excepted. By a critical use of those three archives, and by a careful comparison of the results derived from their study, we obtain the following genealogy of the Star-fishes, which I have already published in my General Morphology (vol. ii. Plate IV. pp. 62–77.)

The most ancient and original group of the Star-fishes, the primary form of the whole phylum, consists of the class of the true Sea-stars (Asterida). This is established by numerous and important arguments in anatomy and the history of development, but above all by the irregular and varying number of the radii, or antimera, which in all other

Echinoderma is limited, without exception, to five. Every Star-fish consists of a central, small, body-disc, all round the circumference of which are attached five or several long articulated arms. *Each arm of the Star-fish essentially corresponds in its organization with an articulated worm of the class of Ring-worms, or Annelida (p. 149).* I therefore consider the Star-fish as a genuine *stock or cormus of five or more articulated worms*, which have arisen by the star-wise growth of a number of buds out of a central mother-worm. The connected members, thus grouped like the rays of a star, have inherited from the mother-worm the common opening of the mouth, and the common digestive cavity (stomach) lying in the central body-disc. The end by which they have grown together, and which fuses in the common central disc, probably corresponds to the posterior end of the original independent worms.

In exactly the same way several individuals of certain kinds of worms are united so as to form a star-like cormus. This is the case in the *Botryllidæ*, compound Ascidians, belonging to the class of the Tunicata. Here also the posterior ends of the individual worms have grown together, and have formed a common outlet for discharges, a central cloaca; whereas at the anterior end each worm still possesses its own mouth. In Star-fishes the original mouths have probably become closed in the course of the historical development of the cormus, or colony, whereas the cloaca has developed into a common mouth for the whole cormus.

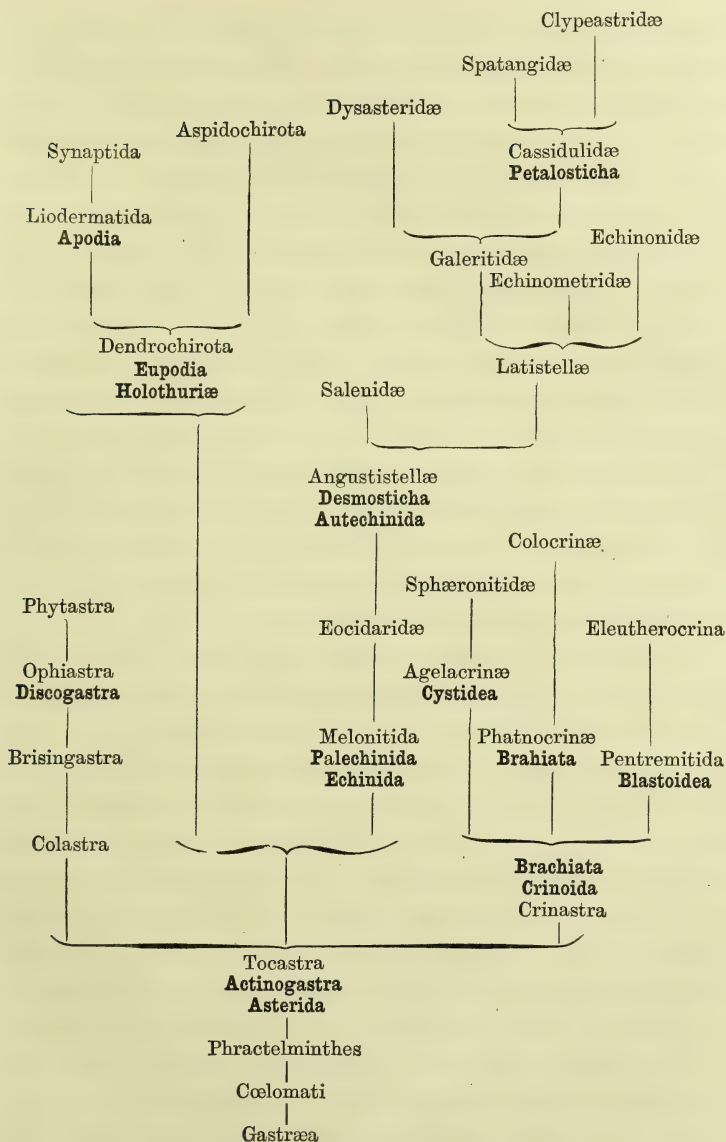
Hence the Star-fishes would be compound stocks of worms which, by the radial formation of buds, have developed out of true articulated worms, or Annelids. This hypothesis is most strongly supported by the comparative

SYSTEMATIC SURVEY

Of the 4 Classes, 9 Sub-classes, and 20 Orders of Star-fishes.

(Compare Gen. Morph. II. Plate IV. pp. 62-67.)

<i>Classes of the Star-fishes.</i>	<i>Sub-classes of the Star-fishes.</i>	<i>Orders of the Star-fishes.</i>	<i>Systematic Name of the Orders.</i>
I. Sea Stars Asterida	I. Sea Stars with ra- diated stomach <i>Actinogastra</i>	1. Primary Stars 2. Articulated Stars 3. Brisinga Stars	1. Tocastra 2. Colastra 3. Brising- astra
	II. Sea Stars with disc- shaped stomach <i>Discogastra</i>	4. Serpent Stars 5. Tree Stars 6. Lily Stars	4. Ophiastrea 5. Phytastrea 6. Crinastrea
	III. Lilies with arms <i>Brachiata</i>	7. Plated Lilies with arms 8. Articulated Lilies with arms	7. Phatnocri- nida 8. Colocrinida
II. Sea Lilies Crinoida	IV. Lilies with buds <i>Blastoidea</i>	9. Regularly budding Lilies 10. Lilies budding on two sides	9. Pentremi- tida 10. Eleuthero- crina
	V. Bladder Lilies <i>Cystidea</i>	11. Bladder Lilies without stalks 12. Bladder Lilies with stalks	11. Agelacri- nida 12. Sphæroni- tida
III. Sea Urchins Echinida	VI. Older Sea Urchins (with more than 20 rows of plates) <i>Palechinida</i>	13. Palechinida with more than 10 rows of ambu- lacrall plates 14. Palechinida with 10 rows of am- bulacrall plates	13. Melonitida 14. Eocidaria
	VII. More recent Sea Urchins (with 20 rows of plates) <i>Autechinida</i>	15. Autechinida with band-like am- bulacrall 16. Autechinida with leaf-like ambulacrall	15. Desmo- sticha 16. Petalo- sticha
IV. Sea Cucumbers Holothuriæ	VIII. Sea Cucumbers with aquatic feet <i>Eupodia</i>	17. Eupodia with scu- tiform tentacles 18. Eupodia with branching ten- tacles	17. Aspidochi- rota 18. Dendrochi- rota
	IX. Sea Cucumbers without aquatic feet <i>Apodia</i>	19. Apodia with water- lungs 20. Apodia without water-lungs	19. Lioderma- tida 20. Synaptida



anatomy, and by the ontogeny of some Star-fishes (Coelastrea), and of segmented worms. The many-jointed Ring-worms (Annelida) in their inner structure are closely allied to the individual arms or radii of the Star-fishes, that is to the original single worms, which each arm represents. Each of the five worms of the Star-fish is a chain composed of a great number of equi-formal members, or metamera, lying one behind the other, like every segmented Worm, and every Arthropod. As in the latter a central nervous cord, the ventral nerve cord, runs along the central line of the ventral wall of each segment. On each metameron there is a pair of non-jointed feet, and besides these, in most cases, one or more hard thorns or bristles similar to those of many Ring-worms. A detached arm of a Star-fish can lead an independent life, and can then, by the radially-directed growth of buds at one end, again become a complete star.

The most important proofs, however, of the truth of my hypothesis are furnished by the ontogeny or the individual development of the Echinoderma. The most remarkable facts of this ontogeny were first discovered in the year 1848 by the great zoologist, Johannes Müller of Berlin. Some of its most important stages are represented on Plates VIII. and IX. (Compare their explanation in the Appendix.) Fig. *A* on Plate IX. shows us a common Sea-star (Uraster), Fig. *B*, a Sea-lily (Comatula), Fig. *C*, a Sea-urchin (Echinus), and Fig. *D*, a Sea-cucumber (Synapta). In spite of the extraordinary difference of form manifested by these four representatives of the different classes of Star-fishes, yet the beginning of their development is identical in all cases. Out of the egg an animal-form

develops which is utterly different from the fully developed Star-fish, but very like the ciliated larvæ of certain segmented Worms (Star-worms and Ring-worms). This peculiar animal-form is generally called the "larva," but more correctly the "nurse" of these Star-fish. It is very small and transparent, swims about by means of a fringe of cilia, and is always composed of two equal symmetrical halves or sides. The fully grown Echinoderm, however—which is frequently more than a hundred times larger, and quite opaque—creeps at the bottom of the sea, and is always composed of at least five co-ordinate pieces, or antimeræ, in the form of radii. Plate VIII. shows the development of the "nurses" of the four Echinoderms represented on Plate IX.

The fully developed Echinoderm arises by a very remarkable process of budding in the interior of the "nurse," of which it retains little more than the stomach. The nurse, erroneously called the "larva," of the Echinoderm, must accordingly be regarded as a solitary worm, which by internal budding produces a second generation, in the form of a stock of star-shaped and connected worms. The whole of this process is a genuine alternation of generations, or metagenesis, not a "metamorphosis," as is generally though erroneously stated. A similar alternation of generations also occurs in many other worms, especially in some star worms (Sipunculidæ), and cord worms (Nemertinae). Now if, bearing in mind the fundamental law of biogeny, we refer the ontogeny of Echinoderma to their phylogeny, then the whole historical development of the Star-fishes suddenly becomes clear and intelligible to us, whereas without this hypothesis it remains an insoluble mystery. (Compare Gen. Morph. ii. pp. 95–99.)

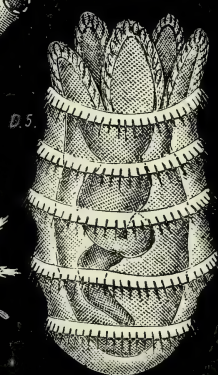
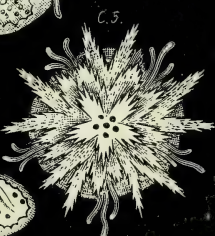
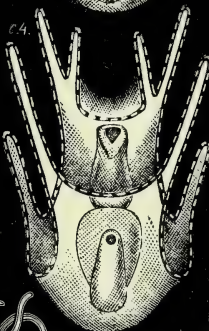
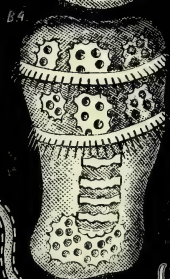
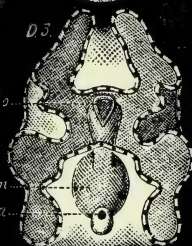
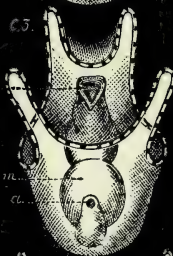
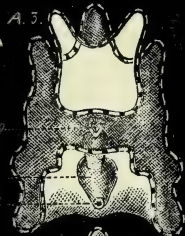
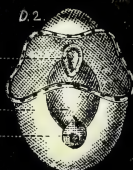
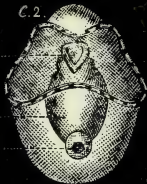
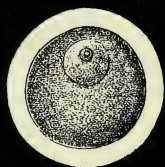
Besides the reasons mentioned, there are many other facts (principally from the comparative anatomy of Echinoderma) which most distinctly prove the correctness of my hypothesis. I established this hypothesis in 1866, without having any idea that *fossil articulated worms* still existed, apparently answering to the hypothetical primary forms. Such have in the mean time, however, really been discovered. In a treatise "On the Equivalent of the North American Taconic Schist in Germany,"* Geinitz and Liébe, in 1867, have described a number of articulated Silurian worms, which completely confirm my suppositions. Numbers of these very remarkable worms are found in an excellent state of preservation in the slates of Würzbach, in the upper districts of Reusz. They are of the same structure as the articulated arm of a Star-fish, and evidently possessed a hard coat of mail, a much denser, more solid cutaneous skeleton than other worms in general. The number of body-segments, or metamera, is very considerable, so that the worms, although no more than a quarter or half an inch in breadth, attained a length of from two to three feet. The excellently preserved impressions, especially those of the *Phyllodocites thuringiacus* and *Crossopodia Henrici*, are so like the arms of many Star-fish (*Colastra*) that their true blood relationship seems very probable. This primæval group of worms, which are most probably the ancestors of Star-fish, I call Mailed worms (*Phracthelminthes*, p. 150.)

The three other classes of Echinoderma evidently arose at a later period out of the class of Sea-stars which have most faithfully retained the original form of the stellate

* "Ueber ein Aequivalent der takonischen Schiefer Nordamerikas in Deutschland."

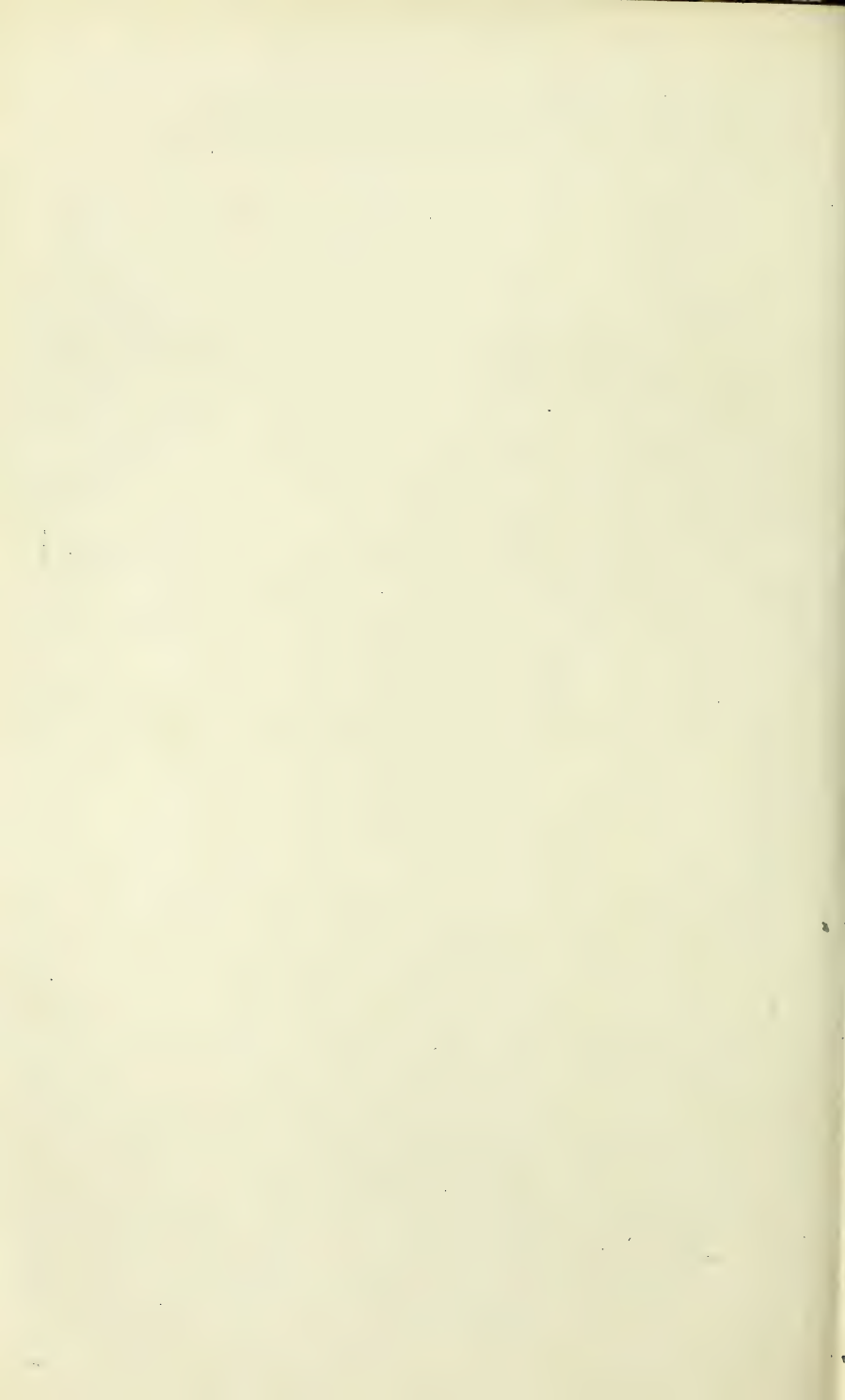
STAR FISHES. FIRST GENERATION. WORM PERSON.

A.1. B.1. C.1. D.1.



STAR FISHES. SECOND GENERATION. WORM STOCK.

*A. Uraster.**B. Comatula.**C. Echinus.**D. Synapta.*



colony of worms. The Sea-lilies, or Crinoida, differ least from them, but having given up the free, slow motion possessed by other Sea-stars, they have become adherent to rocks, etc., and form for themselves a long stalk. Some Encrinites, however (for example, the Comatulæ, Fig. *B*, on Plates VIII. and IX.), afterwards detach themselves from their stalk. The original worm individuals in the Crinoida are indeed no longer preserved in the same independent condition as in the case of the common star-fish; but they nevertheless always possess articulated arms extending from a common central disc. Hence we may unite the Sea-lilies and Sea-stars into a main-class, or branch, characterized as possessing articulated arms (Colobrachia).

In the other two classes of Echinoderma, the Sea-urchins and Sea-cucumbers, the articulated arms are no longer present as independent parts, but, by the increased centralization of the stock, have completely fused so as to form a common, inflated, central disc, which now looks like a simple box or capsule without arms. The original stock of five individuals has apparently degenerated to the form-value of a simple individual, a single person. Hence we may represent these two classes as a branch characterized as being without arms (Lipobrachia), equivalent to those which possess articulated arms. The first of these two classes, that of Sea-urchins (Echinida) takes its name from the numerous and frequently very large thorns which cover the hard shell, which is itself artistically built up of calcareous plates. (Fig. *C*, Plates VIII. and IX.) The fundamental form of the shell itself is a pentagonal pyramid. The Sea-urchins probably developed directly out of the group of Sea-stars. The different classes and orders of

marine lilies and stars which are given in the following table, illustrate the laws of progress and differentiation in a striking manner. In each succeeding period of the earth's history we see the individual classes continually increasing in variety and perfection. (Gen. Morph. ii. Plate IV.)

The history of three of these classes of Star-fish is very minutely recorded by numerous and excellently preserved fossils, but on the other hand, we know almost nothing of the historical development of the fourth class, that of the Sea-cucumbers (Holothuriæ). These curious sausage-shaped Star-fish manifest externally a deceptive similarity to worms. (Fig. D, Plates VIII. and IX.) The skeletal structures in their skin are very imperfect, and hence no distinct remains of their elongated, cylindrical, worm-like body could be preserved in a fossil state. However, from the comparative anatomy of the Holothuriæ, we can infer that they have arisen, by the softening of the cutaneous skeleton, from members of the class of Sea-urchins.

From the Star-fish we turn to the fifth and most highly developed tribe of the invertebrate animals, namely, the phylum of Articulata, or those with *jointed feet* (Arthropoda). As has already been remarked, this tribe corresponds to Linnæus' class of Insects. It contains four classes: (1) the genuine six-legged Insects, or Flies; (2) the eight-legged Spiders; (3) the Centipedes, with numerous pairs of legs; and (4) the Crabs, or Crustacea, whose legs vary in number. The last class breathe water through gills, and may therefore be contrasted as the main-class of gill-breathing Arthropoda, or Gilled Insects (Carides), with the three first classes. The latter breathe air by means of peculiar wind-pipes, or tracheæ, and may therefore appropriately be united

to form the main-class of the trachea-breathing Arthropoda, or Tracheate Insects (Tracheata).

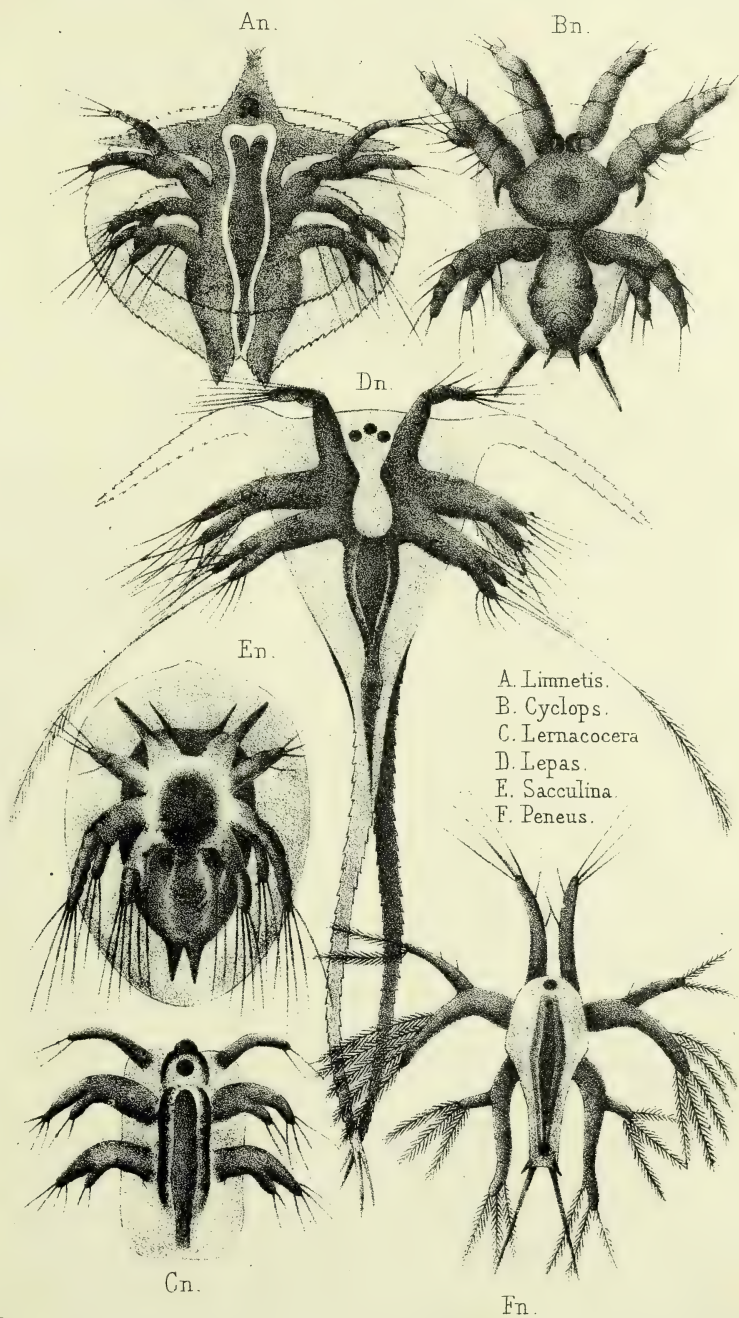
In all animals with articulated feet, as the name indicates the legs are distinctly articulated, and by this, as well as by the strong differentiation of the separate parts of the body, or metamera, they are sharply distinguished from Ringed worms, with which Bär and Cuvier classed them. They are, however, in every respect so like the Ringed worms that they can scarcely be considered altogether distinct from them. They, like the Ringed worms, possess a very characteristic form of the central nervous system, the so-called ventral marrow, which commences in a gullet-ring encircling the mouth. From other facts also, it is evident that the Arthropoda developed at a late period out of articulated worms. Probably either the Wheel Animalcules or the Ringed worms are their nearest blood relations in the Worm tribe. (Gen. Morph. ii. Plate V. pp. 85–102.)

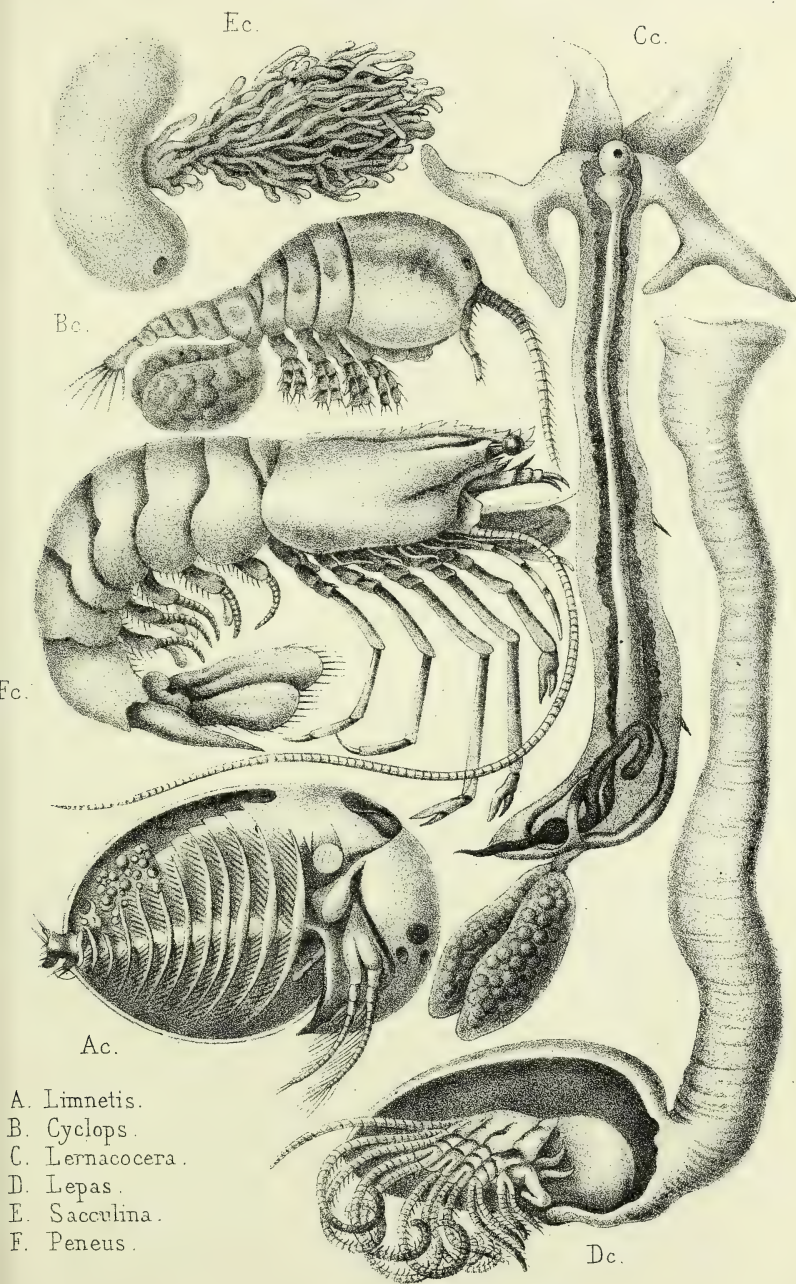
Now, although the derivation of the Arthropoda from ringed Worms may be considered as certain, still it cannot with equal assurance be maintained that the whole tribe of the former has arisen out of one branch of the latter. For several reasons seem to support the supposition that the Gilled Arthropods have developed out of a branch of articulated worms, different from that which gave rise to the Tracheate Arthropods. But on the whole it remains more probable that both main-classes have arisen out of one and the same group of Worms. In this case the Tracheate Insects—Spiders, Flies, and Centipedes—must have branched off at a later period from the gill-breathing Insects, or Crustacea.

The pedigree of the Arthropoda can on the whole be clearly made out from the palæontology, comparative ana-

tomy, and ontogeny of its four classes, although here, as everywhere else, many details remain very obscure. Not until the history of the individual development of all the different groups has become more accurately known than it is at present, can this obscurity be removed. The history of the class of Gilled Insects, or Crabs (Carides), is at present that best known to us; they are also called encrusted animals (Crustacea), on account of the hard crust or covering of their body. The ontogeny of these animals is extremely interesting and, like that of Vertebrate animals, distinctly reveals the essential outlines of the history of their tribe, that is, their phylogeny. Fritz Müller, in his work, "Für Darwin,"¹⁶ which has already been referred to, has explained this remarkable series of facts in a very able manner.

The common primary form of all Crabs, which in most cases is even now the first to develop out of the egg, is originally one and the same, the so-called *Nauplius*. This remarkable primæval crab represents a very simple form of articulated animal, the body of which in general has the form of a roundish, oval, or pear-shaped disc, and has on its ventral side only three pairs of legs. The first of these is uncloven, the two subsequent pairs are forked. In front, above the mouth, lies a simple, single eye. Although the different orders of the Crustacean class differ very widely from one another in the structure of their body and its appendages, yet the early *Nauplius* form always remains essentially the same. In order to be convinced of this, let the reader look attentively at Plates X. and XI., a more detailed explanation of which is given in the Appendix. On Plate XI. we see the fully developed representatives of six





different orders of Crabs, a Leaf-footed Crab (*Limnetis*, Fig. *A c*) ; a Stalked Crab (*Lepas*, Fig. *D c*) ; a Root Crab, (*Sacculina*, Fig. *E c*) ; a Boatman Crab (*Cyclops*, Fig. *B c*) ; a Fish Louse (*Lernæocera*, Fig. *C c*) ; and, lastly, a highly developed Shrimp (*Peneus*, Fig. *F c*) These six crabs vary very much, as we see, in the entire form of body, in the number and formation of the legs, etc. When, however, we look at the earliest stages, or "nauplius," of these six different classes, after they have crept out of the egg—those marked with corresponding letters on Plate X. (Fig. *A n*—*F n*)—we shall be surprised to find how much they agree. The different forms of Nauplius of these six orders differ no more from one another than would six different "good species" of one genus. Consequently, we may with assurance infer a common derivation of all those orders from a common Primæval Crab, which was essentially like the Nauplius of the present day.

The pedigree on p. 177 will show how we may at present approximately conceive the derivation of the twenty orders of Crustacea enumerated on p. 176, from the common primary form of the Nauplius. Out of the Nauplius form—which originally existed as an independent genus—the five legions of lower Crabs developed as diverging branches in different directions, which in the systematic survey of the class are united as Segmented Crabs (*Entomostraca*). The higher division of Mailed Crabs (*Malacostraca*) have likewise originated out of the common Nauplius form. The *Nebalia* is still a direct form of transition from the Phyllopods to the Schizopods, that is, to the primary form of the stalk-eyed and sessile-eyed Mailed Crabs. The Nauplius at this stage gives rise to another larva form,

SYSTEMATIC SURVEY

Of the 7 Legions and 20 Orders of Crabs, or Crustacea.

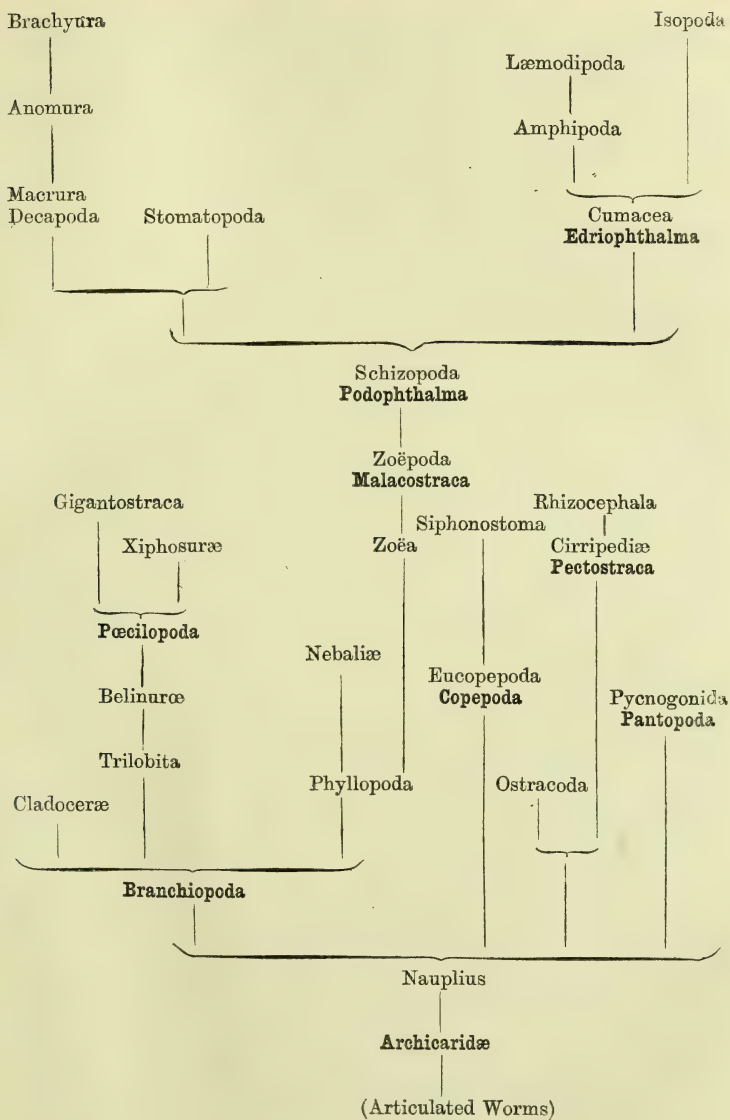
<i>Legions of the Crustaceæ.</i>	<i>Orders of the Crustaceæ.</i>	<i>Systematic Name of the Orders.</i>	<i>Name of a Genus as an example.</i>
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I. ENTOMOSTRACA, *Lower Crustacea*, or Segmented Crabs (not passing through the actual Zoëa form in youth).

I. Branchiopoda Gill-footed Crabs	1. Primæval Crabs	1. Archicarida	Nauplius
	2. Leaf-foot Crabs	2. Phyllopoda	Limnetis
	3. Trilobites	3. Trilobita	Paradoxides
	4. Water Fleas	4. Cladocera	Daphnia
	5. Bivalve Crabs	5. Ostracoda	Cypris
II. Pectostraca Fixed Crabs	6. Barnacle Crabs	6. Cirripedia	Lepas
	7. Root Crabs	7. Rhizocephala	Sacculina
III. Copepoda Oar-footed Crabs	8. Boatmen Crabs	8. Eucopepoda	Cyclops
	9. Fish Lice	9. Siphonostoma	Lernæocera
IV. Pantopoda No-body Crabs	10. No-body Crabs	10. Pycnogonida	Nymphon
	11. Spear-tails	11. Xiphosura	Limulus
V. Pæcilopoda Shield Crabs	12. Giant Crabs	12. Gigantosthraca	Eurypterus

II. MALACOSTRACA, *Higher Crustacea*, or Mailed Crabs (passing through the Zoëa form in youth).

V. Podoph- thalma Stalk-eyed Mailed Crabs	13. Zoëa Crabs	13. Zoëpoda	Zoëa
	14. Split-legged Crabs	14. Schizopoda	Mysis
	15. Mouth-footed Crabs	15. Stomatopoda	Squilla
	16. Ten-footed Crabs	16. Decapoda	Peneus
VII. Edrioph- thalma Mailed Crabs with sessile eyes	17. Cuma Crabs	17. Cumacea	Cuma
	18. Flea Crabs	18. Amphipoda	Gammarus
	19. Wizard Crabs	19. Læmodipoda	Caprella
	20. Louse Crabs	20. Isopoda	Oniscus



the so-called Zoëa, which is of great importance. The order of Schizopoda, those with cloven feet (*Mysis*, etc.), probably originated from this curious Zoëa; they are at present still directly allied, through the *Nebalia* to the Phyllopoda, those with foliaceous feet. But of all living crabs the Phyllopods are the most closely allied to the original primary form of the Nauplius. Out of the Schizopoda the stalk-eyed and sessile-eyed Mailed Crabs, or Malacostraca, developed as two diverging branches in different directions: the former through shrimps (*Peneus*, etc.), the latter through the Cumacea (*Cuma*, etc.), which are still living and closely allied to the Schizopoda. Among those with stalked eyes is the river crab (cray-fish), the lobster, and the others with long tails, or the *Macrura*, out of which, in the chalk period, the short-tailed crabs, or *Brachyura*, developed by the degeneration of the tail. Those with sessile eyes divide into the two branches of Flea-crabs (*Amphipoda*) and Louse-crabs (*Isopoda*); among the latter are our common Rock-slaters and Wood-lice.

The second main-class of Articulated animals, that of the Tracheata, or air-breathing Tracheate Insects* (Spiders, Centipedes, and Flies) did not develop until the beginning of the palæolithic era, after the close of the archilithic period, because all these animals (in contrast with the aquatic crabs) are originally inhabitants of land. It is evident that the Tracheata can have developed only after the lapse of the Silurian period when terrestrial life first began. But as fossil remains of spiders and insects have been found, even in the

* The English word "Insects" might with advantage be used in the Linnæan sense for the whole group of Arthropods. In this case the Hexapod Insects might be spoken of as the Flies.—E. R. L.

carboniferous beds, we can pretty accurately determine the time of their origin. The development of the first Tracheate Insects out of gill-bearing Zoëa-crabs, must have taken place between the end of the Silurian and the beginning of the coal period, that is, in the Devonian period.

Gegenbaur, in his excellent "Outlines of Comparative Anatomy,"²¹ has lately endeavoured to explain the origin of the Tracheata by an ingenious hypothesis. The system of tracheæ, or air pipes, and the modifications of organization dependent upon it, distinguish Flies, Centipedes, and Spiders so much from other animals, that the conception of its first origin presents no inconsiderable difficulties to phylogeny. According to Gegenbaur, of all living Tracheate Insects, the Primæval Flies, or Archiptera, are most closely allied to the common primary form of the Tracheata. These insects—among which we may especially mention the delicate Day flies (*Ephemera*), and the agile dragon-flies (*Libellula*)—in their earliest youth, as larvæ, frequently possess *external tracheate gills* which lie in two rows on the back of the body, and are shaped like a leaf or paint-brush. Similar leaf or paint-brush shaped organs are met with as real water-breathing organs or gills, in many crabs and ringed worms, and, moreover, in the latter as real dorsal appendages or limbs. The "tracheate gills," found in the larvæ of many primæval winged insects, must in all probability be explained as "*dorsal limbs*," and as having developed out of the corresponding appendages of the *Annelida*, or possibly as having really arisen out of similar parts in *Crustacea* long since extinct. The present tracheal respiration of the Tracheata developed at a later period out of respiration through "tracheate gills." The tracheate gills

themselves, however, have in some cases disappeared, and in others become transformed into the *wings* of the Flies. They have disappeared entirely in the classes of Spiders and Centipedes, and these groups must accordingly be conceived of as degenerated or peculiarly developed lateral branches of the Fly class, which at an early period branched off from the common primary form of Flies ; Spiders probably did so at an earlier period than Centipedes. Whether that common primary form of all Tracheata, which in my General Morphology I have named Protracheata, did develop directly out of genuine Ringed worms, or at first out of Crustacea of the Zoëa form (Zoëpoda, p. 177) will probably be settled at some future time by a more accurate knowledge and comparison of the ontogeny of the Tracheata, Crustacea, and Annelida. However, the root of the Tracheata, as well as that of the Crustacea, must in any case be looked for in the group of Ringed worms.

The genuine Spiders (Arachnida) are distinguished from Flies by the absence of wings, and by four pairs of legs ; but, as is distinctly seen in the Scorpion-spiders and Tarantulæ, they, like Flies, possess in reality only three pairs of genuine legs. The apparent "fourth pair of legs" in spiders (the foremost) are in reality a pair of feelers. Among the still existing Spiders, there is a small group which is probably very closely allied to the common primary form of the whole class ; this is the order of Scorpion-spiders, or Solifugæ, (Solpuga, Galeodes), of which several large species live in Africa and Asia, and are dreaded on account of their poisonous bite. Their body consists—as we suppose to have been the case in the common ancestor of the Tracheata—of a head

possessing several pairs of feelers like legs, of a thorax, to the three rings of which are attached three pairs of legs, and of a hinder, body, or abdomen, consisting of many distinct rings. In the articulation of their body, the Solifugæ are therefore in reality more closely related to flies than to other spiders. Out of the Devonian Primæval Spiders, which were nearly related to the Solifugæ of the present day, the Long Spiders, the Tailor Spiders, and the Round Spiders probably developed as three diverging branches.

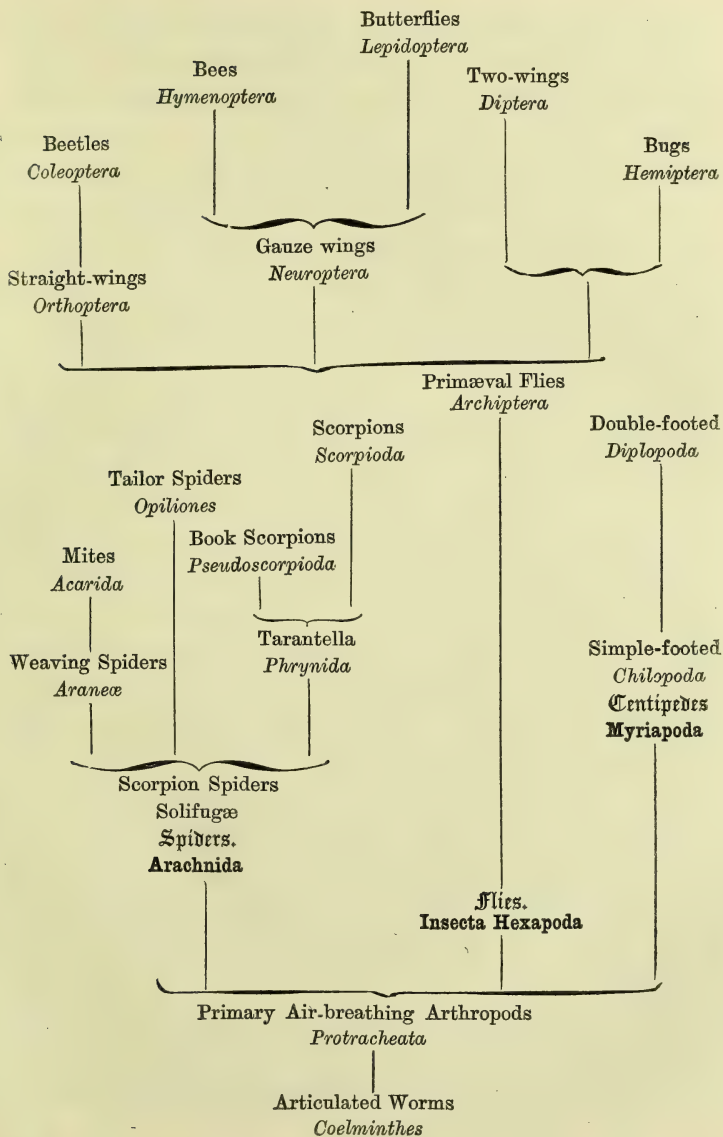
The *Long Spiders* (Arthrogastres), in which the earlier articulation of body has been better preserved than in Round Spiders, appear to be the older and more original forms. The most important members of this sub-class are the scorpions, which are connected with the Solifugæ through the Tarantella (or Phrynidæ). The small book scorpions, which inhabit our libraries and herbariums, appear as a degenerate lateral branch from the true scorpions. Mid-way between the Scorpions and Round Spiders are the long-legged Tailor-spiders (Opiliones) which have possibly arisen out of a special branch of the Solifugæ. The Pycnogonida, or No-body Crabs, and the Arctisca, or Bear Worms—still generally included among Long Spiders—must be completely excluded from the class of Spiders; the former belong to the Crustacea, the latter to Ringed worms.

Fossil remains of Long Spiders are found in the Coal. The second sub-class of the Arachnida, the *Round Spiders* (Sphærogastres), first appear in the fossil state in the Jura, that is, at a very much later period. They have developed out of a branch of the Solifuga, by the rings of the body becoming more and more united with one another. In the true *Spinning Spiders* (Araneæ), which we admire on

SYSTEMATIC SURVEY

Of the 3 Classes and 17 Orders of the Tracheata.

<i>Classes of the Tracheata.</i>	<i>Sub-Classes of the Tracheata.</i>	<i>Order of the Tracheata.</i>	<i>Two Names of Genera as examples.</i>	
I. Spiders Arachnida	I. Long spiders <i>Arthrogastres</i>	1. Scorpion spiders <i>Solifugæ</i>	{ Solpuga Galeodes	
		2. Tarantella <i>Phrynida</i>	{ Phrynnus Thelyphonus	
		3. Scorpions <i>Scorpioda</i>	{ Scorpio Buthus	
		4. Book scorpions <i>Pseudoscorpioda</i>	{ Obisium Chelifer	
		5. Tailor spiders <i>Opilionida</i>	{ Phalangium Opilio	
	II. Round spiders <i>Sphærogastres</i>	6. Spinning spiders <i>Araneæ</i>	{ Epeira Mygale	
		7. Mites <i>Acarida</i>	{ Sarcoptes Demodex	
	II. Centipedes Scolopendria or Myriapoda	III. Simple-footed <i>Chilopoda</i>	8. Simple-footed <i>Chilopoda</i>	{ Scolopendra Geophilus
		IV. Double-footed <i>Diplopoda</i>	9. Double-footed <i>Diplopoda</i>	{ Julus Polydesmus
		V. Chewing <i>Masticantia</i>	10. Primitive flies <i>Archiptera</i>	{ Ephemera Libellula
11. Gauze-wings <i>Neuroptera</i>			{ Hemerobius Phryganea	
12. Straight-wings <i>Orthoptera</i>			{ Locusta Forficula	
13. Beetles <i>Coleoptera</i>			{ Cicindela Melolontha	
14. Bee-wings <i>Hymenoptera</i>			{ Apis Formica	
VI. Sucking <i>Sugentia</i>			15. Bugs <i>Hemiptera</i>	{ Aphis Cimex
			16. Two-wings <i>Diptera</i>	{ Culex Musca
		17. Butterflies <i>Lepidoptera</i>	{ Bombyx Papilio	



account of their delicate skill in weaving, the union of the joints of the trunk, or metamera, goes so far, that the trunk now consists of only two pieces, of a head-breast (cephalothorax) with jaws, feelers, and four pairs of legs, and of a hinder body without appendages, where the spinning warts are placed. In *Mites* (Acarida), which have probably arisen by degeneration (especially by parasitism) out of a lateral branch of Spinning Spiders, even these two trunk pieces have become united and now form an unsegmented mass.

The class of *Scolopendria*, *Myriapoda*, or Centipedes, the smallest and poorest in forms of the four classes of Arthropoda, is characterized by a very elongated body, like that of a segmented Ringed worm, and often possesses more than a hundred pairs of legs. But these animals also originally developed out of a six-legged form of Tracheata, as is distinctly proved by the individual development of the millipede in the egg. Their embryos have at first only three pairs of legs, like genuine insects, and only at a later period do the posterior pairs of legs bud, one by one, from the growing rings of the hinder body. Of the two orders of Centipedes (which in our country live under barks of trees, in moss, etc.) the round, *double-footed* ones (Diplopoda) probably did not develop until a later period out of the older flat, *single-footed* ones (Chilopoda), by successive pairs of rings of the body uniting together. Fossil remains of the Chilopoda are first met with in the Jura period.

The third and last class of the Arthropoda breathing through tracheæ, is that of the *Flies*, or *Insects*, in the narrow sense of the word (Insecta, or Hexapoda), the largest of all

classes of animals, and next to that of Mammalia, also the most important. Although Flies develop a greater variety of genera and species than all other animals taken together, yet these are all in reality only superficial variations of a single type, which is entirely and constantly preserved in its essential characteristics. In all Flies the three divisions of the trunk—head, breast (thorax), and hinder body—are quite distinct. The *hinder body*, or *abdomen*, as in the case of spiders, has no articulated appendages. The central division, the *breast* or *thorax*, has on its ventral side three pairs of legs, on its back *two pairs of wings*. It is true that, in very many Flies, one or both pairs of wings have become reduced in size or have even entirely disappeared; but the comparative anatomy of Flies distinctly shows that this deficiency has arisen only gradually by the degeneration of the wings, and that all the Flies existing at present are derived from a common, primary Fly, which possessed three pairs of legs and two pairs of wings. (Compare p. 256.) These wings, which so strikingly distinguish Flies from all other Arthropoda, probably arose, as has been already shown, out of the tracheate gills which may still be observed in the larvæ of the ephemeral flies (*Ephemera*) which live in water.

The head of Flies universally possesses, besides the eyes, a pair of articulated feelers, or antennæ, and also three jaws upon each side of the mouth. These *three pairs of jaws*, although they have arisen in all Flies from the same original basis, by different kinds of adaptation, have become changed to very varied and remarkable forms in the various orders, and are therefore employed for distinguishing and characterizing the main divisions

of the class. In the first place, we may distinguish two main divisions, namely, Flies with *chewing* mandibles (Masticantia) and Flies with *sucking* mouths (Sugentia). On a closer examination each of these two divisions may again be divided into two sub-groups. Among chewing Flies, or Masticantia, we may distinguish the biting and the licking ones. *Biting flies* (Mordentia) comprise the most ancient and primæval winged Flies, the gauzy-winged (Neuroptera), straight-winged (Orthoptera), and beetles (Coleoptera). *Licking flies* (Lambentia) are represented by the one order of skin-winged (Hymenoptera) Flies. We distinguish two groups of *Sucking Flies*, or Sugentia, namely, those which prick and those which sip. There are two orders of pricking Flies (Pungentia), those with half wings (Hemiptera) and gnats and blow-flies, (Diptera); butterflies are the only *sipping* Flies (Sorbentia), Lepidoptera.

Biting Flies, and indeed the order of *Primæval Flies* (Archiptera, or Pseudoneuroptera) are nearest akin to the still living Flies, and include the most ancient of all Flies, the primary forms of the whole class (hence also those of all Tracheata). Among them are, first of all, the Ephemeral Flies (Ephemera) whose larvæ which live in water, in all probability still show us in their tracheæ-gills the organs out of which the wings of Flies were originally developed. This order further contains the well known dragon-flies, or Libellula, the wine-glass sugar mites (Lepisma), the hopping Flies with bladder-like feet (Physopoda), and the dreaded Termites, fossil remains of which are found even in coal. The order

of Gauze-winged Flies (Neuroptera), probably developed directly out of the primæval Flies, which differ from them only by their perfect series of transformations. Among them are the gauze-flies (Planipennia), caddis-flies (Phryganida), and fan-flies (Strepsiptera). Fossil Flies, which form the transition from the primæval Flies (Libellula) to the gauze-winged (Sialidæ), are found even in coal (Dictyophylebia).

The order of *Straight-winged Flies* (Orthoptera) developed at an early period out of another branch of the primæval Flies by differentiation of the two pairs of wings. This division is composed of one group with a great variety of forms—cockroaches, grasshoppers, crickets, etc. (Ulonata)—and of a smaller group consisting only of the well-known earwigs (Labidura), which are characterised by nippers at the hinder end of their bodies. Fossil remains of cockroaches, as well as of crickets and grasshoppers, have been found in coal.

Fossil remains of the fourth order of Biting Flies, *beetles* (Coleoptera) likewise occur in coal. This extremely comprehensive order—the favourite one of amateurs and collectors—shows more clearly than any other what infinite variety of forms can be developed externally by adaptation to different conditions of life, without the internal structure and the original form of the body being in any way essentially changed. Beetles have probably developed out of a branch of the straight-winged Flies, from which they differ only in their transformations (larva, pupa, etc.)

The one order of *Licking Flies*, namely, the interesting

group of the *Bees*, or *Skin-winged Flies* (Hymenoptera), is closely allied to the four orders of biting Flies. Among them are those Flies which have risen to such an astonishing degree of mental development, of intellectual perfection, and strength of character, by their extensive division of labour, formation of communities and states, and surpass in this not merely most invertebrate animals, but even most animals in general. This may be said especially of all ants and bees, also of wasps, leaf-wasps, wood-wasps, gall-wasps, etc. They are first met with in a fossil state in the oolites, but they do not appear in greater numbers until the tertiary period. Probably these insects developed either out of a branch of the primæval Flies or the gauze-winged Flies.

Of the two orders of *Pricking Flies* (Hemiptera and Diptera), that containing the *Half-winged Flies* (Hemiptera), also called Beaked Flies (Rhynchota), is the older of the two. It includes three sub-orders, viz., the leaf-lice (Homoptera), the bugs (Heteroptera), and lice (Pediculina). Fossil remains of the first two classes are found in the oolites; but an ancient Fly (Eugereon) is found in the Permian system, and seems to indicate the derivation of the Hemiptera from the Neuroptera. Probably the most ancient of the three sub-orders of the Hemiptera are the Homoptera, among which, besides the actual leaf-lice, are the shield-lice, leaf-fleas, and leaf-crickets, or Cicadæ. Lice have probably developed out of two different branches of Homoptera, by continued degeneration (especially by the loss of wings); bugs, on the other hand, by the perfecting and differentiation of the two pairs of wings.

The second order of *pricking flies*, namely, the *Two-winged Flies* (Diptera), are also found in a fossil state in the oolites, together with Half-winged Flies; but they probably developed out of the Hemiptera by the degeneration of the hind wings. In Diptera the fore wings alone have remained perfect. The principal portion of this order consists of the elongated gnats (Nemocera) and of the compact blow-flies and house-flies (Brachycera), the former of which are probably the older of the two. However, remains of both are found in the oolitic period. The two small groups of lice-flies (Pupipara) forming chrysales, and the hopping-fleas (Aphaniptera), probably developed out of the Diptera by degeneration resulting from parasitism.

The eighth and last order of Flies, and at the same time the only one with mouth-parts adapted to sipping liquids, consists of *moths* and *butterflies* (Lepidoptera). This order appears, in several morphological respects, to be the most perfect class of Flies, and accordingly was the last to develop. For we only know of fossil remains of this order from the tertiary period, whereas the three preceding orders extend back to the oolites, and the four biting orders even to the coal period. The close relationship between some moths (Tineæ) and (Noctuæ), and some caddis-flies (Phryganida) renders it probable that butterflies have developed from this group, that is, out of the order of Gauze-winged Flies, or Neuroptera.

The whole history of Flies, and, moreover, the history of the whole tribe of Arthropoda, essentially confirms the great laws of differentiation and perfecting which, according to Darwin's theory of selection, must be

considered as the necessary results of Natural Selection. The whole tribe, so rich in forms, begins in the Archilithic period with the class of *Crabs* breathing by gills, and with the lowest *Primæval Crabs*, or *Archicaridæ*. The form of these *Primæval Crabs*, which were developed out of segmented worms, is still approximately preserved by the remarkable *Nauplius*, in the common larval stage of so many *Crabs*. Out of the *Nauplius*, at a later period, the curious *Zoëa* was developed, which is the common larval form of all the higher or mailed crabs (*Malacostraca*), and, at the same time, possibly of that *Arthropod* which at first breathed through *tracheæ*, and became the common ancestor of all *Tracheata*. This *Devonian* ancestor, which must have originated between the end of the *Silurian* and the beginning of the *Coal* period, was probably most closely related to the still living *Primæval Flies*, or *Archiptera*. Out of these there developed, as the main tribe of the *Tracheata*, the class of *Flies*, from the lowest stage of which the *spiders* and *centipedes* separated as two diverging branches. Throughout a long period there existed only the four biting orders of *Flies*—the *Primæval flies*, *Gauze-wings*, *Straight-wings*, and the *Beetles*, the first of which is probably the common primary form of the three others. It was only at a much later period that the *Licking*, *Pricking*, and *Sipping* flies developed out of the *Biting* ones, which retained the original form of the three pairs of jaws most distinctly. The following table will show once more how these orders succeeded one another in the history of the earth.

A. Flies with Chewing Mouths Masticantia	I. Biting Flies <i>Mordentia</i>	1. Primæval winged	{ M.I.
		<i>Archiptera</i>	{ A.A.
		2. Gauze-winged	{ M.C.
		<i>Neuroptera</i>	{ A.A.
	II. Licking Flies <i>Lambentia</i>	3. Straight-winged	{ M.I.
		<i>Orthoptera</i>	{ A.D.
		4. Beetles	{ M.C.
		<i>Coleoptera</i>	{ A.D.
B. Flies with Sucking Mouths Sugentia	III. Stinging Flies <i>Pungentia</i>	5. Skin-winged	{ M.C.
		<i>Hymenoptera</i>	{ A.A.
		6. Half-winged	{ M.I.
		<i>Hemiptera</i>	{ A.A.
	IV. Sipping Flies <i>Sorbentia</i>	7. Tway-flies	{ M.C.
		<i>Diptera</i>	{ A.D.
		8. Butterflies	{ M.C.
		<i>Lepidoptera</i>	{ A.A.

Note.—The difference in the metamorphosis or transformation and in the development of the wings of the eight individual orders of Flies is also specified by the following letters: M.I. = Imperfect Metamorphosis. M.C. = Perfect Metamorphosis. (Compare Gen. Morph. ii. p. 99.) A.A. = Equal wings (fore and hinder wings are the same, or differ but little). A.D. = Unequal wings (fore and hinder wings very different in structure and texture, occasioned by strong differentiation).

CHAPTER XX.

PEDIGREE AND HISTORY OF THE ANIMAL KINGDOM.

III. VERTEBRATE ANIMALS.

The Records of the Creation of Vertebrate Animals (Comparative Anatomy, Embryology, and Palæontology).—The Natural System of Vertebrate Animals.—The Four Classes of Vertebrate Animals, according to Linnaeus and Lamarck.—Their increase to Nine Classes.—Main Class of the Tube-hearted, or Skull-less Animals (the Lancelet)—Blood Relationship between the Skull-less Fish and the Tunicates.—Agreement in the Embryological Development of Amphioxus and Ascidia.—Origin of the Vertebrate Tribe out of the Worm Tribe.—Main Class of Single-nostriled, or Round-mouthed Animals (Hag and Lampreys).—Main Class of Anamniote Animals, devoid of Amnion.—Fishes (Primæval Fish, Cartilaginous Fish, Osseous Fish).—Mud-fish, or Dipneusta.—Sea Dragons, or Halisauria.—Frogs and Salamanders, or Amphibia (Mailed Amphibia, Naked Amphibia).—Main Class of Amniote Animals, or Amniota.—Reptiles (Primary Reptiles, Lizards, Serpents, Crocodiles, Tortoises, Flying Reptiles, Dragons, Beaked Reptiles).—Birds (Feather-tailed, Fan-tailed, Bush-tailed).

NOT one of the natural groups of organisms—which we have designated as tribes, or phyla, on account of the blood-relationship of all the species included in them—is of such great and exceeding importance as the tribe of Vertebrate Animals. For, according to the unanimous opinion of all zoologists, man also is a member of the tribe; and his whole organization and development cannot possibly be distinguished from that of other Vertebrate animals. But as from

the individual history of human development, we have already recognized the undeniable fact that, in developing out of the egg, man at first does not differ from other Vertebrate animals, and especially from Mammals, we must necessarily come to the conclusion, in regard to the palæontological history of his development, that man has, historically, actually developed out of the lower Vertebrata, and that he is directly derived from lower Mammals. This circumstance, together with the many high interests which, in other respects, entitle the Vertebrata to more consideration than other organisms, justifies us in examining the pedigree of the Vertebrata and its expression in the natural system, with special care.

Fortunately, the records of creation, which must in all cases be our guide in establishing pedigrees, are especially complete in this important animal tribe, from which our own race has arisen. Even at the beginning of our century Cuvier's comparative anatomy and palæontology, and Bär's ontogeny of the Vertebrate animals, had brought us to a high level of accurate knowledge on this matter. Since then it is especially due to Johannes Müller's and Rathke's investigations in comparative anatomy, and most recently to those of Gegenbaur and Huxley, that our knowledge of the natural relationships among the different groups of Vertebrata has become enlarged. It is especially Gegenbaur's classical works, penetrated as they are throughout with the fundamental principles of the Theory of Descent, which have demonstrated that the material of comparative anatomy receives its true importance and value only by the application of the Theory of Descent, and this in the case of all animals, but especially in that in the Vertebrate tribe.

Here, as everywhere else, analogies must be traced to Adaptation, homologies to Transmission by Inheritance. When we see that the limbs of the most different Vertebrata, in spite of their exceedingly different external forms, nevertheless possess essentially the same internal structure; when we see that in the arm of a man and ape, in the wing of a man or a bird, in the breast fins of whales and sea-dragons, in the fore-legs of hoofed animals and frogs, the same bones always lie in the same characteristic position, articulation and connection—we can only explain this wonderful agreement and homology by the supposition of a common transmission by inheritance from a single primary form. On the other hand, the striking differences of these homologous bodily parts proceed from adaptation to different conditions of existence. (Compare Plate IV.)

Ontogeny, or the individual history of development, like comparative anatomy, is of especial importance to the pedigree of the Vertebrata. The first stages of development arising out of the egg are essentially identical in all Vertebrate animals, and retain their agreement the longer, the nearer the respective Vertebrate animal forms, when fully developed, stand to one another in the natural system, that is, in the pedigree. How far this agreement of germ forms, or embryos, extends, even in the most highly developed Vertebrate animals, I have already had occasion to explain (vol. i. pp. 306–309). The complete agreement in form and structure, for example, in the embryos of a man and a dog, of a bird and a tortoise, existing in the stages of development represented on Plates II. and III., is a fact of incalculable importance, and furnishes us with the most important data for the construction of their pedigree.

Finally, the palæontological records of creation are also of especial value in the case of these same Vertebrate animals; for their fossil remains belong for the most part to the bony skeleton, a system of organs which is of the utmost importance for understanding their general organization. It is true that here, as in all other cases, the fossil records are exceedingly imperfect and incomplete, but more important remains of extinct Vertebrate animals have been preserved in a fossil state, than of most other groups of animals; and single fragments frequently furnish the most important hints as to the relationship and the historical succession of the groups.

The name of *Vertebrate Animals* (Vertebrata), as I have already said, originated with the great Lamarck, who towards the end of the last century comprised under this name, Linnæus' four higher classes of animals, viz. Mammals, Birds, Amphibious animals, and Fishes. Linnæus' two lower classes, Insects and Worms, Lamarck contrasted to the Vertebrata as *Invertebrata*, later also called *Evertebrata*.

The division of the Vertebrata into the four classes above named was retained also by Cuvier and his followers, and in consequence by many zoologists down to the present day. But in 1822 Blanville, the distinguished anatomist, found out by comparative anatomy—which Bär did almost at the same time from the ontogeny of Vertebrata—that Linnæus' class of Amphibious animals was an unnatural union of two very different classes. These two classes were separated as early as 1820, by Merrin, as two main groups of Amphibious animals, under the names of Pholidota and Batrachia. The *Batrachia*, which are at present (in a restricted sense) called Amphibious animals, comprise Frogs,

Salamanders, gilled Salamanders, Cæcilia, and the extinct Labyrinthodonta. Their entire organization is closely allied to that of Fishes. The *Pholidota*, or Reptiles, on the other hand, are much more closely allied to Birds. They comprise lizards, serpents, crocodiles, and tortoises, and the groups of the mesolithic Dragons, Flying reptiles, etc.

In conformity with this natural division of Amphibious animals into two classes, the whole tribe of Vertebrate animals was divided into two main groups. The first main group, containing Amphibious animals and Fishes, breathe throughout their lives, or in early life, by means of gills, and are therefore called *gilled Vertebrata* (Branchiata, or Anallantoida). The second main group—Reptiles, Birds, and Mammals—breathe at no period of their lives through gills, but exclusively through lungs, and hence may appropriately be called Gill-less, or *Vertebrata with lungs* (Abranchiata, or Allantoida). However correct this distinction may be, still we cannot remain satisfied with it if we wish to arrive at a true natural system of the vertebrate tribe, and at a right understanding of its pedigree. In this case, as I have shown in my General Morphology, we are obliged to distinguish three other classes of Vertebrate animals, by dividing what has hitherto been regarded as the class of fishes into four distinct classes. (Gen. Morph. vol. ii. Plate VII. pp. 116–160.)

The first and lowest of these classes comprises the *Skull-less* animals (Acrania), or animals with *tubular hearts* (Leptocardia), of which only one representative now exists, namely, the remarkable little Lancelet (*Amphioxus lanceolatus*). Nearly allied to this is the second class, that of the *Single-nostriled* animals (Monorrhina), or *Round-mouthed*

animals (Cyclostoma), which includes the Hags (Myxinoida) and Lampreys (Petromyzonta). The third class contains only the genuine Fish (Pisces): the Mud-fishes (Dipneusta) are added to these as a fourth class, and form the transition from Fish to Amphibious animals. This distinction, which, as will be seen immediately, is very important for the genealogy of the Vertebrate animals, increases the original number of Vertebrate classes from four to eight.

In most recent times a ninth class of Vertebrata has been added to these eight classes. Gegenbaur's recently published investigations in comparative anatomy prove that the remarkable class of *Sea-dragons* (Halisauria), which have hitherto been included among Reptiles, must be considered quite distinct from these, and as a separate class which branched off from the Vertebrate stock, even before the Amphibious animals. To it belong the celebrated large Ichthyosauri and Plesiosauri of the oolitic and chalk periods, and the older Simosauri of the Trias period, all of which are more closely allied to Fish than to Amphibious animals.

These nine classes of Vertebrate animals are, however, by no means of the same genealogical value. Hence we must divide them, as I have already shown in the Systematic Survey on p. 133, into four distinct main-classes or tribes. In the first place, the three highest classes, Mammals, Birds, and Reptiles, may be comprised as a natural main-class under the name of *Amnion animals* (Amnionata). The *Amnionless animals* (Anamnionata), naturally opposed to them as a second main-class, include the four classes of Batrachians, Sea-dragons, Mud-fish, and Fishes. The seven classes just named, the Anamnionata as well as the Amnionata, agree among one another in numerous characteristics, which dis-

tinguish them from the two lowest classes (the single-nostriled and tubular-hearted animals). Hence we may unite them in the natural main group of *Double-nostriled* animals (Amphirrhina). Finally, these Amphirrhina on the whole are much more closely related to those animals with round mouths or single nostrils than to the skull-less or tube-hearted animals. We may, therefore, with full justice class the single and double-nostriled animals into one principal main group, and contrast them as *animals with skulls* (Craniota), or *bulbular hearts* (Pachycardia), to the one class of *skull-less animals*, or *animals with tubular hearts*. This classification of the Vertebrate animals proposed by me renders it possible to obtain a clear survey of the nine classes in their most important genealogical relations. The systematic relationship of these groups to one another may be briefly expressed by the following table.

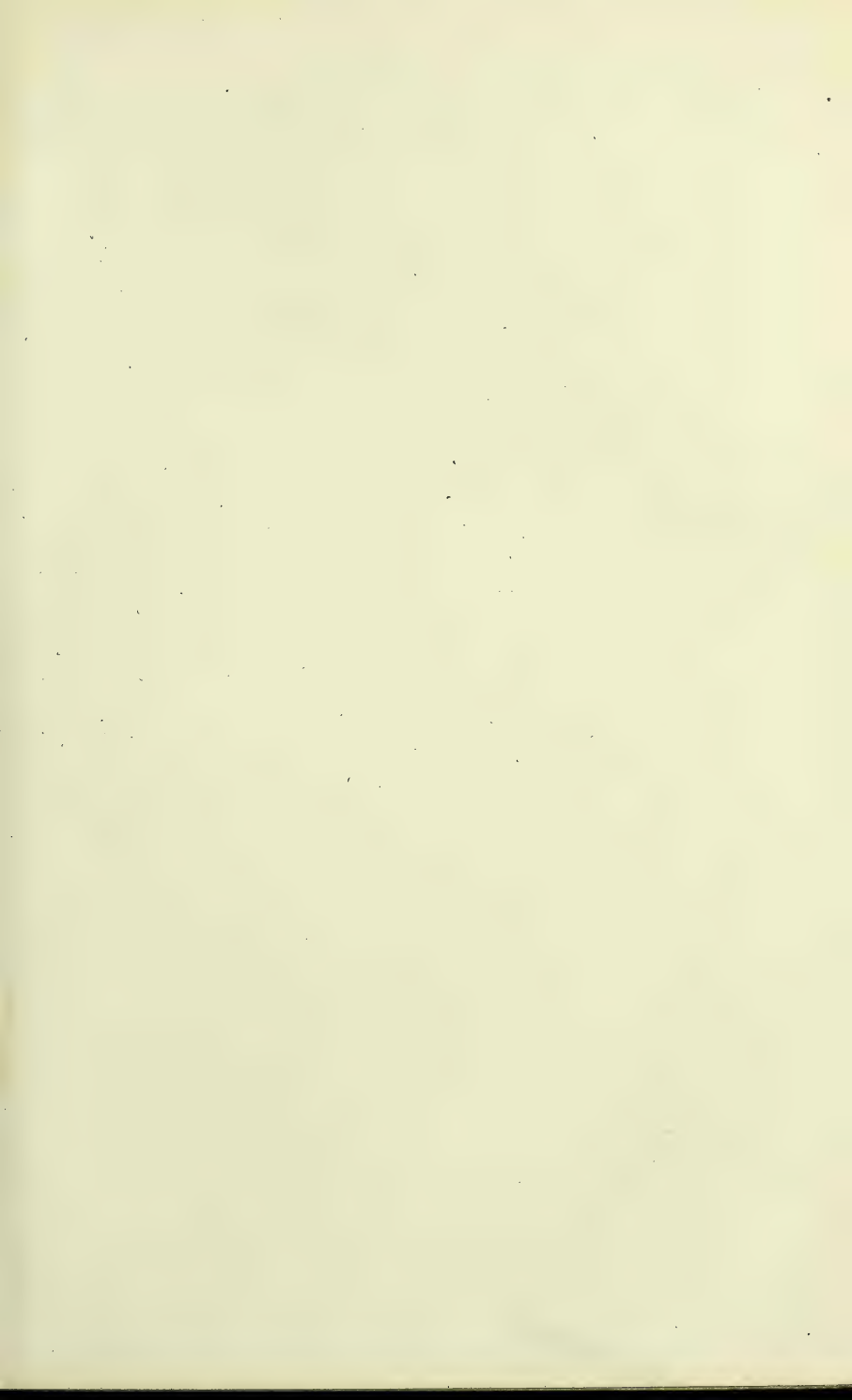
A.		1. Tubular hearts 1. Leptocardia		
Skull-less Animals				
(Acrania)				
B. Animals with Skulls (Craniota) or Thick Hearts (Pachycardia)	{	a. Single-nostriled animals <i>Monorrhina</i>	{ 2. Round-mouths 2. Cyclostoma	
		b. Double nostriled animals <i>Amphir- rhina</i>	{ 3. Fish 3. Pisces	
			I. Non- Amnionate	{ 4. Mud-fish 4. Dipneusta
				Anamnia
		II. Amnion- ate. Amniota	{ 6. Batrachians 6. Amphibia	
			{ 7. Reptiles 7. Reptilia	
			{ 8. Birds 8. Aves	
			{ 9. Mammals 9. Mammalia	

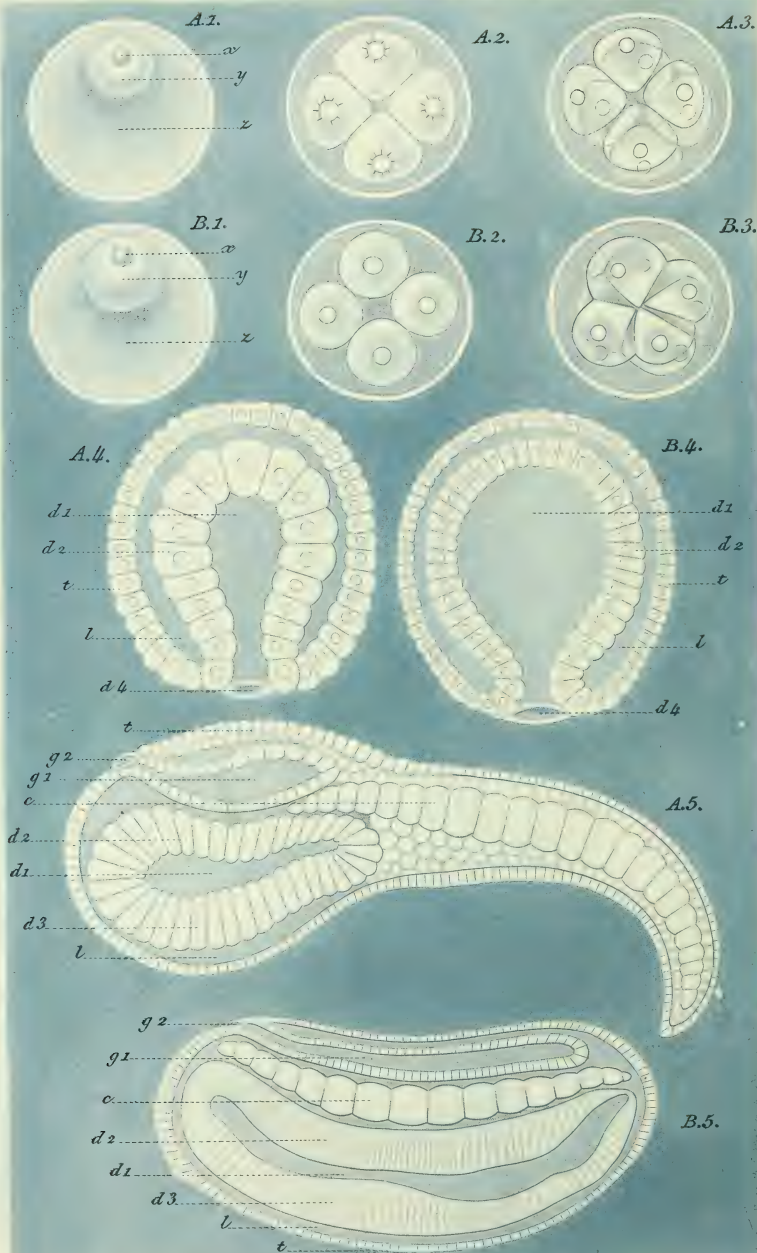
The only one representative of the first class, the small *lanceolate fish*, or *Lancelet* (*Amphioxus lanceolatus*) (Plate XIII. Fig. B), stands at the lowest stage of organization

of all the Vertebrate animals known to us. This exceedingly interesting and important animal, which throws a surprising light upon the older roots of our pedigree, is evidently the last of the Mohicans—the last surviving representative of a lower class of Vertebrate animals, very rich in forms, and very highly developed during the primordial period, but which unfortunately could leave no fossil remains on account of the absence of all solid skeleton. The Lancelet still lives widely distributed in different seas; for instance, in the Baltic, North Sea, and Mediterranean, where it generally lies buried in the sand on flat shores. The body, as the name indicates, has the form of a narrow lanceolate leaf, pointed at both extremities. When full grown it is about two inches long, of a white colour and semi-transparent. Externally, the little lanceolate animal is so little like a vertebrate animal that Pallas, who first discovered it, regarded it as an imperfect naked snail. It has no legs, and neither head, skull, nor brain. Externally, the fore end of the body can be distinguished from the hinder end only by the open mouth. But still the Amphioxus in its internal structure possesses those most important features, which distinguish all Vertebrate animals from all Invertebrate animals, namely, the spinal rod and spinal marrow. The *spinal rod* (*Chorda dorsalis*) is a straight, cylindrical, cartilaginous staff, pointed at both ends, forming the central axis of the internal skeleton, and the basis of the vertebral column. Directly above the spinal rod, on its dorsal side, lies the *spinal marrow* (*medulla spinalis*), likewise originally a straight but internally hollow cord, pointed at both ends. This forms the principal piece and centre of the nervous system in all Vertebrate animals. (Compare above

vol. i. p. 303.) In all Vertebrate animals without exception, man included, these important parts of the body during the embryological development out of the egg, originally begin in the same simple form, which is retained throughout life by the *Amphioxus*. It is only at a later period that the brain develops by the expansion of the fore end of the spinal marrow, and out of the spinal rod the skull which encloses the brain. As these two important organs do not develop at all in the *Amphioxus*, we may justly call the class represented by it, *Skull-less animals* (Acrania), in opposition to all the others, namely, to the *animals with skulls* (Craniota). The Skull-less animals are generally called *tubular-hearted* (Leptocardia), because a centralized heart does not as yet exist, and the blood is circulated in the body by the contractions of the tubular blood-vessels themselves. The Skulled animals, which possess a centralized, thick-walled, bulb-shaped heart, ought then by way of contrast to be called *bulbular-hearted* animals (Pachycardia).

Animals with skulls and central hearts evidently developed gradually in the later primordial period out of those without skulls and with tubular hearts. Of this the ontogeny of skulled animals leaves no doubt. But whence are these same skull-less animals derived? It is only very lately that an exceedingly surprising answer has been given to this important question. From Kowalewsky's investigations, published in 1867, on the individual development of the *Amphioxus* and the adhering Sea-squirts (*Ascidia*) belonging to the class of mantled animals (*Tunicata*), it has been proved that the ontogenies of these two entirely different looking animal-forms agree in the first stage of development in a most remarkable manner. The freely swimming larvæ of the



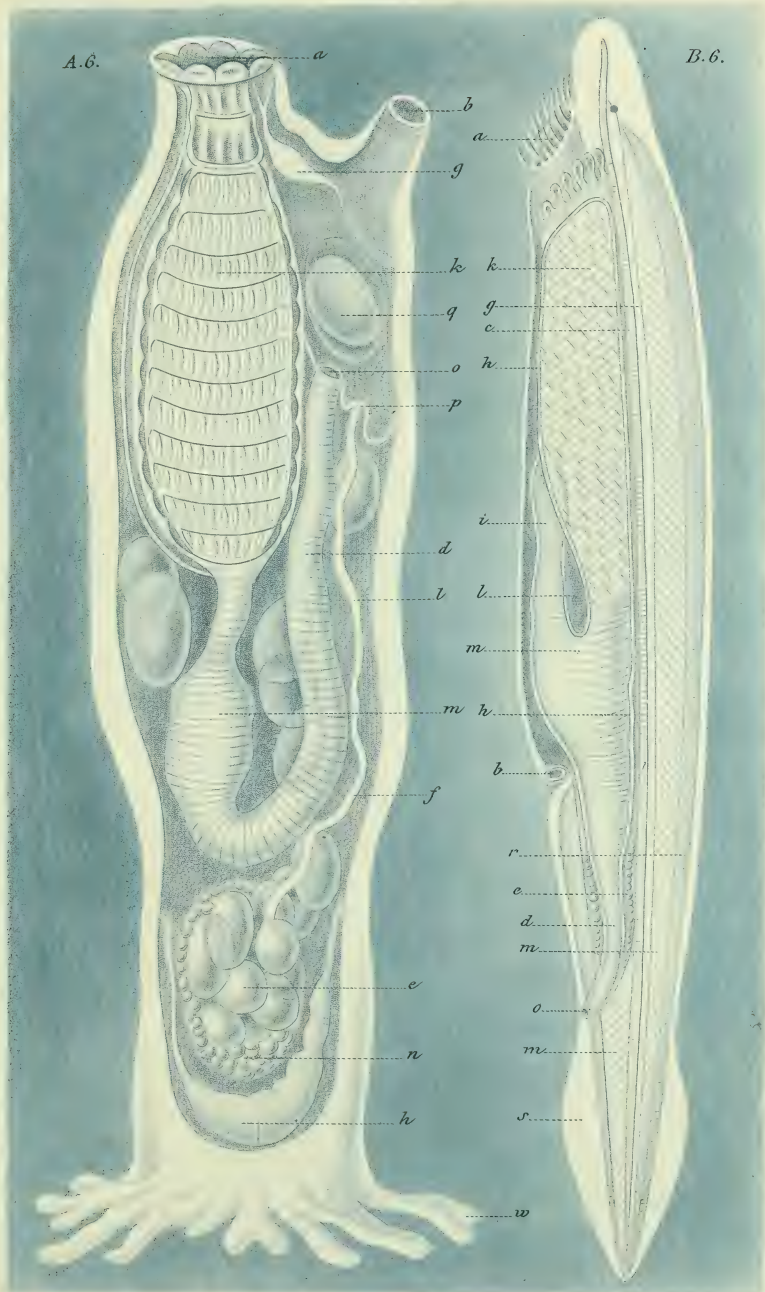


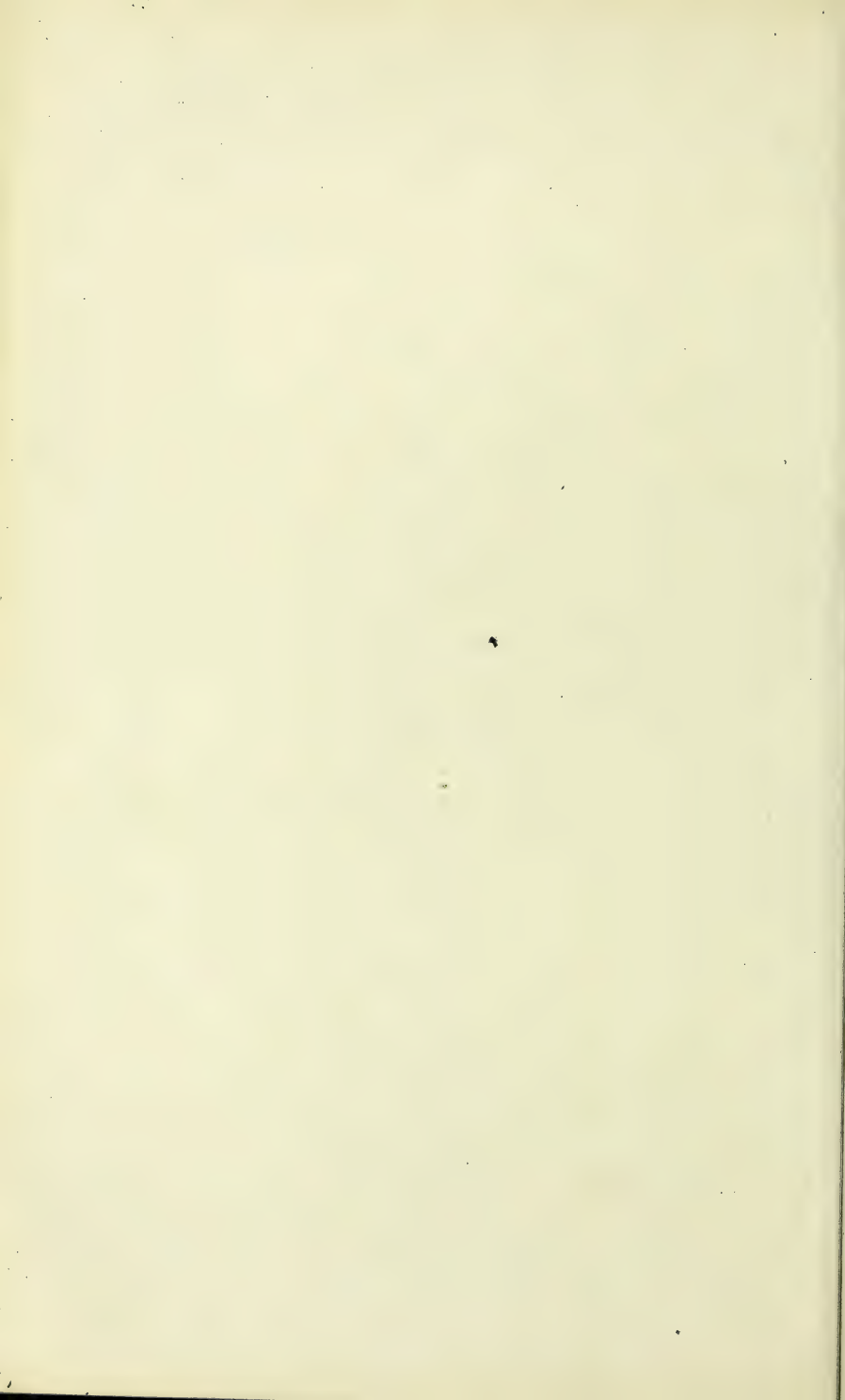
Ascidians (Plate XII. Fig. *A*) develop the undeniable beginning of a spinal marrow (Fig. 5 *g*) and of a spinal rod (Fig. 5 *c*), and this moreover in entirely the same way as does the *Amphioxus*. (Plate XIII. Fig. *B*.) It is true that in the Ascidians these most important organs of the Vertebrate animal-body do not afterwards develop further. The Ascidians take on a retrograde transformation, become attached to the bottom of the sea, and develop into shapeless lumps, which when looked upon externally would scarcely be supposed to be animals. (Plate XIII. Fig. *A*.) But the spinal marrow, as the beginning of the central nervous system, and the spinal rod, as the first basis of the vertebral column, are such important organs, so exclusively characteristic of Vertebrate animals, that we may from them with certitude infer the true blood relationship of Vertebrate with Tunicate animals. Of course we do not mean to say by this, that Vertebrate animals are derived from Tunicate animals, but merely that both groups have arisen out of a common root, and that the Tunicates, of all the Invertebrata, are the nearest blood relations of the Vertebrates. It is quite evident that genuine Vertebrate animals developed progressively during the primordial period (and the skull-less animals first) out of a group of worms, from which the degenerate Tunicate animals arose in another and a retrograde direction. (Compare the more detailed explanation of Plates XII. and XIII. in the Appendix.)

Out of the Skull-less animals there developed, in the first instance, a second low class of Vertebrate animals, which still stands far below that of fish, and which is now represented only by the Hags (*Myxinoida*) and Lampreys (*Petromyzonta*). This class also, on account of the absence

of all solid parts, could, unfortunately, as little as the Skull-less animals leave fossil remains. From its whole organization and ontogeny it is quite evident that it represents a very important intermediate stage between the Skull-less animals and Fishes, and that its few still existing members are only the last surviving remains of a probably very highly developed animal group which existed towards the end of the primordial period. On account of the curious mouth possessed by the Hags and Lampreys, which they use for sucking, the whole class is usually called *Round-mouthed* animals (Cyclostoma). The name of *Single-nostriled* animals (Monorrhina) is still more characteristic. For all Cyclostoma possess a simple, single nasal tube, whereas, in all other Vertebrate animals (with the exception of the Amphioxus) the nose consists of two lateral halves, a right and a left nostril. We are therefore enabled to comprise these latter (Anamnionata and Amnionata) under the heading, *double-nostriled* animals (Amphirrhina). All the Amphirrhina possess a fully developed jaw-skeleton (upper and under jaw), whereas it is completely wanting in the Monorrhina.

Apart also from the peculiar nasal formation, and the absence of jaws, the Single-nostriled animals are distinguished from those with double nostrils by many peculiarities. Thus they want the important sympathetic nervous system, and the spleen which the Amphirrhina possess. Of the swimming bladder, and the two pairs of legs—which all double-nostriled animals have, at least in their embryonic conditions—not a trace exists in the Single-nostriled animals, which is the case also in the Skull-less animals. Hence, we are surely justified in completely





separating the Monorrhina, as we have separated the Skullless animals, from the Fishes, with which they have hitherto been erroneously classed.

We owe our first accurate knowledge of the Monorrhina, or Cyclostoma, to the great zoologist, Johannes Müller of Berlin; his classical work on the "Comparative Anatomy of the Myxinoida" forms the foundation of our modern views on the structure of the Vertebrate animals. He distinguished two distinct groups among the Cyclostoma, which we shall consider as sub-classes.

The first sub-class consists of the Hags (*Hyperotreta*, or *Myxinoida*). They live in the sea as parasites upon other fish, into whose skin they penetrate (*Myxine*, *Bdellostoma*). Their organ of hearing has only one annular canal, and their single nasal tube penetrates the palate. The second sub-class, that of Lampreys, or Prides (*Hyperoartia*, or *Petromyzontia*) is more highly developed. It includes the well-known Lamperns, or Nine-eyes, of our rivers (*Petromyzon fluviatilis*), with which most persons are acquainted. They are represented in the sea by the frequently larger marine or genuine Lampreys (*Petromyzon marinus*). The nasal tube of these single-nostriled animals does not penetrate the palate, and in the auricular organ there are two annular canals.

All existing Vertebrate animals, with the exception of the Monorrhina and *Amphioxus* just mentioned, belong to the group which we designate as Double-nostriled animals (*Amphirrhina*). All these animals possess (in spite of the great variety in the rest of their forms) a nose consisting of two lateral halves, a jaw-skeleton, a sympathetic nervous system, three annular canals connected with the auricular

SYSTEMATIC SURVEY

Of the 4 Main-classes, 9 Classes, and 26 Sub-classes of Vertebrata.

Gen. Morph. vol. ii. Plate VII. pp. 116-160.

I. Skull-less (**Acrania**), or Tube-hearted (**Leptocardia**).

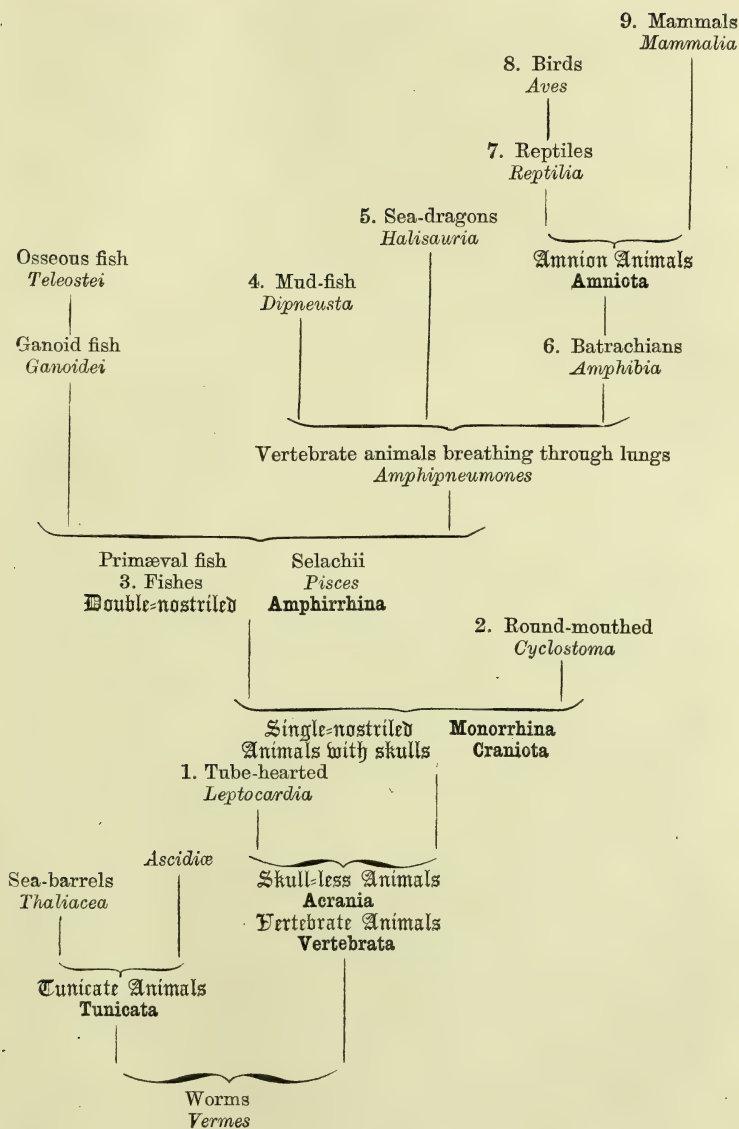
Vertebrata without head, without skull and brain, without centralized heart.

1. Skull-less Acrania	I. Tube-hearted <i>Leptocardia</i>	{ 1. Lancelet	1. Amphioxus
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II. Animals with skulls (**Craniota**) and with thick-walled hearts (**Pachycardia**).

Vertebrata with head, with skull and brain, with centralized heart.

<i>Main-classes of the Skulled Animals.</i>	<i>Classes of the Skulled Animals.</i>	<i>Sub-classes of the Skulled Animals.</i>	<i>Systematic Name of the Sub-classes.</i>
2. Single- Nostriled Monorrhina	II. Round mouths <i>Cyclostoma</i>	{ 2. Hags, or Mucous Fish 3. Lampreys, or Pride	2. Hyperotreta (Myxinoida) 3. Hyperoartia (Petromyzontia)
3. Non-am- nionate Anamnion- ata	III. Fish <i>Pisces</i>	{ 4. Primæval fish 5. Ganoid fish 6. Osseous fish	4. Selachii 5. Ganoides 6. Teleostei
	IV. Mud-fish <i>Dipneusta</i>	{ 7. Mud-fish	7. Protopteri
	V. Sea-dragons <i>Halisauri</i>	{ 8. Primæval dragons 9. Snake-dragons 10. Fish-dragons	8. Simosauria 9. Plesiosauria 10. Ichthyosauria
	VI. Batrachians <i>Amphibia</i>	{ 11. Mailed Batra- chians 12. Naked Batra- chians	11. Phractamphibia 12. Lissamphibia
		{ 13. Primary reptiles 14. Lizards 15. Serpents 16. Crocodiles 17. Tortoises 18. Flying reptiles 19. Dragons 20. Beaked reptiles	13. Tocosauria 14. Lacertilia 15. Ophidia 16. Crocodilia 17. Chelonia 18. Pterosauria 19. Dinosauria 20. Anomodontia
	VII. Reptiles <i>Reptilia</i>	{ 21. Long-tailed 22. Fan-tailed 23. Bush-tailed	21. Saururæ 22. Carinatæ 23. Ratitæ
4. Amnion Animals Amnionata	VIII. Birds <i>Aves</i>	{ 24. Cloacal animals 25. Pouched animals 26. Placental animals	24. Monotrema 25. Marsupialia 26. Placentalia
	IX. Mammals <i>Mammalia</i>		



sac, and a spleen. Further, all Double-nostriled animals possess a bladder-shaped expansion of the gullet, which, in Fish, has developed into the swimming bladder, but in all other Double-nostriled animals into lungs. Finally, in all Double-nostriled animals there exist in the youngest stage of growth the beginnings of two pairs of extremities, or limbs, a pair of fore legs, or breast fins, and a pair of hinder legs, or ventral fins. One of these pairs of legs sometimes degenerates (as in the case of eels, whales, etc.), or both pairs of legs (as in Cæciliæ and serpents) either degenerate or entirely disappear; but even in these cases there exists some trace of their original beginning in an early embryonic period, or the useless remains of them may be found in the form of rudimentary organs. (Compare above, vol. i. p. 13.)

From all these important indications we may conclude with full assurance that all double-nostriled animals are derived from a single common primary form, which developed either directly or indirectly during the primordial period out of the Monorrhina. This primary form must have possessed the organs above mentioned, and also the beginning of a swimming bladder and of two pairs of legs or fins. It is evident, that of all still living double-nostriled animals, the lowest forms of sharks are most closely allied to this long since extinct, unknown, and hypothetical primary form, which we may call the Primary Double-nostriled animals (*Proselachii*). We may therefore look upon the group of primæval fish, or *Selachii*, to which the *Proselachii* probably belonged, as a primary group, not only of the Fish class, but of the whole main-class of double-nostriled animals.

The class of *Fish* (*Pisces*) with which we accordingly

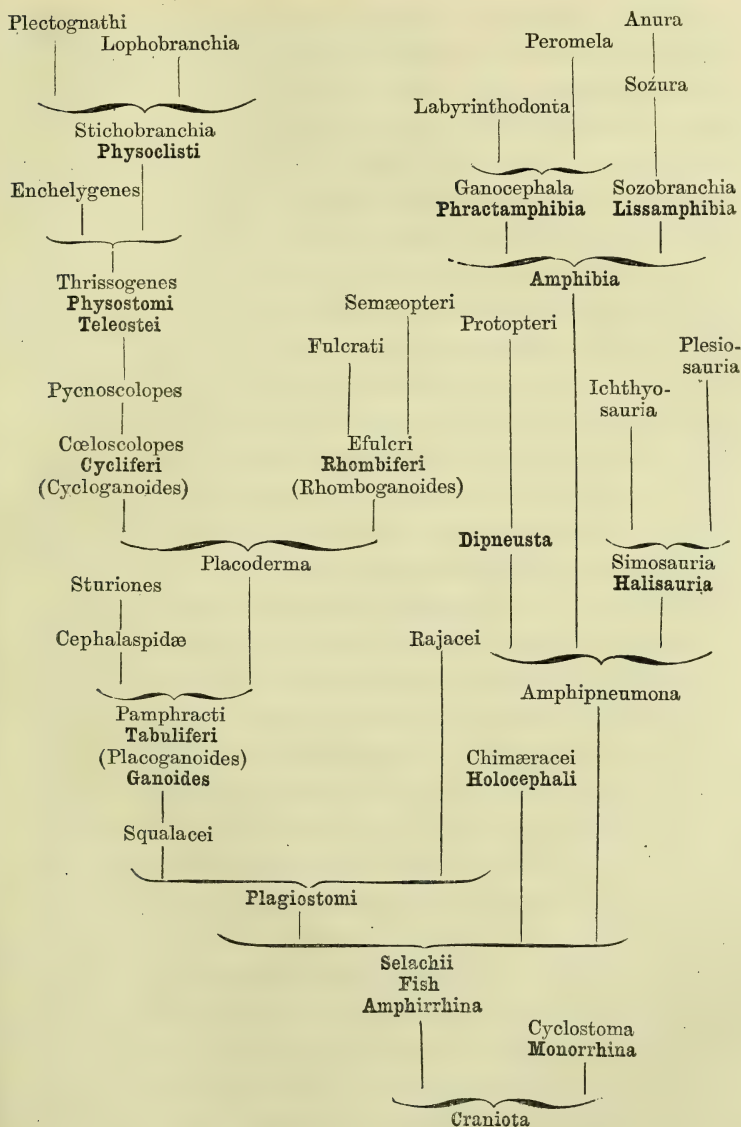
begin the series of Double-nostriled animals, is distinguished from the other six classes of the series by the swimming bladder never developing into lungs, but acting only as a hydrostatic apparatus. Agreeing with this, we find that in fish the nose is formed by two blind holes in front of the mouth, which never pierce the palate so as to open into the cavity of the mouth. In the other six classes of double-nostriled animals, both nostrils are changed into air passages which pierce the palate, and thus conduct air to the lungs. Genuine fish (after the exclusion of the Dipneusta) are accordingly the only double-nostriled animals which exclusively breathe through gills and never through lungs. In accordance with this, they all live in water, and both pairs of their legs have retained the original form of paddling fins.

Genuine fish are divided into three distinct sub-classes, namely, Primæval fish, Ganoid fish, and Osseous fish. The oldest of these, where the original form has been most faithfully preserved, is that of the *Primæval fish* (Selachii). Of these there still exist Sharks (Squali), and Rays (Rajæ), which are classed together as cross-mouthed fishes (Plagiostomi), and the strange and grotesquely formed Sea-cats, or *Chimæracei* (Holocephali). These primary fish of the present day, which are met with in all seas, are only poor remains of the prevailing animal groups, rich in forms, which the Selachii formed in the earlier periods of the earth's history, and especially during the palæolithic period. Unfortunately all Primæval fish possess a cartilaginous, never a completely osseous skeleton, which is but little, if at all, capable of being petrified. The only hard parts of the body which could be preserved in a fossil state, are the

SYSTEMATIC SURVEY

Of the 7 Legions and 15 Orders of the Fishes.

<i>Sub-classes of Fishes.</i>	<i>Legions of Fishes.</i>	<i>Orders of Fishes.</i>	<i>Examples from the Orders.</i>
A. Primæval Fish Selachii	I. Transverse mouths <i>Plagiostomi</i>	1. Sharks <i>Squalacei</i>	Sharks, dog-fish
		2. Rays <i>Rajacei</i>	Spiked rays, electric rays, etc.
	II. Sea-Cats <i>Holocephali</i>	3. Sea-Cats <i>Chimæracei</i>	Chimæra, Calorrhyn- chias
		B. Ganoid Fish Ganoides	III. Mailed Ganoid Fish <i>Tabuliferi</i>
IV. Angular-scaled Ganoid Fish <i>Rhombiferi</i>	5. Sturgeons <i>Sturiones</i>		Spoon-sturgeons, stur- geons, sterlet, etc.
	6. <i>Efuleri</i>		Double-finned
V. Round-scaled Ganoid Fish <i>Cycliferi</i>	7. <i>Fulcrati</i>		Palæoniscus, bony pike, etc.
	8. <i>Semæopteri</i>		African finny pike, etc.
C. Osseous Fish Teleostei	VI. Osseous Fish with an air passage to the swimming bladder <i>Physostomi</i>	9. <i>Cæloscolopes</i>	Holoptychius, Cœlacan- thides, etc.
		10. <i>Pycnoscolopes</i>	Coccolepida, Amiadæ, etc.
	VII. Osseous Fish without an air passage to the swimming bladder <i>Physoclisti</i>	11. Herring species <i>Thrissogenes</i>	Herrings, salmon, carp, etc.
		12. Eel species <i>Enchelygenes</i>	Eels, snake eels, electric eels, etc.
		13. <i>Stichobranchii</i>	Perch, wrasse, turbot, etc.
		14. <i>Plectognathi</i>	Trunk fish, globe fish, etc.
		15. <i>Lophobranchii</i>	Pipe fish, sea horses, etc.



teeth and fin-spikes. These are found in the older formations in such quantities, varieties, and sizes, that we may, with certainty, infer a very considerable development of Primæval fish in those remote ages. They are even found in the Silurian strata, which contain but few remains of other Vertebrata, such as Enamelled fish (and these only in the most recent part, that is, in the upper Silurian). By far the most important and interesting of the three orders of Primæval fish are Sharks; of all still living double-nostriled animals, they are probably most closely allied to the original primary form of the whole group, namely, to the Proselachii. Out of these Proselachii, which probably differed but little from genuine Sharks, Enamelled fish, and the present Primæval fish, in all probability, developed in one direction, and the Dipneusta, Sea-dragons, and Amphibia in another.

The *Ganoid*, or *Enamelled fish* (Ganoides), in regard to their anatomy stand midway between the Primæval and the Osseous fish. In many characteristics they agree with the former, and in many others with the latter. Hence, we infer that genealogically they form the transition from Primæval to Osseous fish. The Ganoids are for the most part extinct, and more nearly so than the Primæval fish, whereas they were developed in great force during the entire palæolithic and mesolithic periods. Ganoid fish are divided into three legions according to the form of their external covering, namely, Mailed, Angular-scaled, and Round-scaled. The *Mailed Ganoid fish* (Tabuliferi) are the oldest, and are directly allied to the Selachii, out of which they originated. Fossil remains of them, though rare, are found even in the upper Silurian (*Pteraspis ludensis* of the

Ludlow strata). Gigantic species of them, coated with strong bony plates, are found in the Devonian system. But of this legion there now lives only the small order of Sturgeons (Sturiones), including the Spade-sturgeons (Spatularidæ), and those Sturgeons (Accipenseridæ) to which belong, among others, the Huso, which yields isinglass, or sturgeon's sound, and the Caviar-sturgeon, whose eggs we eat in the shape of caviar, etc. Out of the mailed Ganoid fish, the angular and round-scaled ones probably developed as two diverging branches. The *Angular-scaled Ganoid fish* (Rhombiferi)—which can be distinguished at first sight from all other fish by their square or rhombic scales—are at present represented only by a few survivors, namely, the Finny Pike (Polypterus) in African rivers (especially the Nile), and by the Bony Pike (Lepidosteus) in American rivers. Yet during the palæolithic and the first half of the mesolithic epochs this legion formed the most numerous group of fishes. The third legion, that of *Round-scaled Ganoid fish* (Cycliferi), was no less rich in forms, and lived principally during the Devonian and Coal periods. This legion, of which the Bald Pike (Amia), in North American rivers, is the only survivor, was especially important, inasmuch as the third sub-class of fish, namely, Osseous fish, developed out of it.

Osseous fish (Teleostei) include the greater portion of the fish of the present day. Among these are by far the greater portion of marine fish, and all of our fresh-water fish except the Ganoid fish just mentioned. This class is distinctly proved by numerous fossils to have arisen about the middle of the Mesolithic epoch out of Ganoid fish, and moreover out of the Round-scaled, or Cycliferi.

The Thrissopidæ of the Oolitic period (Thrissops, Leptolepis, Tharsis), which are most closely allied to the herrings of the present day, are probably the oldest of all Osseous fish, and have directly arisen out of Round-scaled Ganoid fish, closely allied to the existing *Amia*. In the older Osseous fish of the legion called *Physostomi*, as also in the Ganoides, the swimming bladder throughout life was connected with the throat by a permanent air passage (a kind of windpipe). This is still the case with all the fish belonging to this legion, namely, with herrings, salmon, carp, shad, eels, etc. However, during the chalk period this air passage, in some of the *Physostomi*, became constricted and closed, and the swimming bladder was thus completely separated from the throat. Hence there arose a second legion of Osseous fish, the *Physoclisti*, which did not attain their actual development until the tertiary epoch, and soon far surpassed the *Physostomi* in variety. To this legion belong most of the sea fish of the present day, especially the large families of the Turbot, Tunny, Wrasse, Crowfish, etc., further, the Lock-jaws (*Plectognathi*), Trunk fish, and Globe-fish and the Bushy-gills (*Lophobranchi*), viz., Pipe-fish, and Sea-horses. There are, however, only very few *Physoclisti* among our river fish, for instance, Perch and Sticklebacks; the majority of river fish are *Physostomi*.

Midway between genuine Fish and Amphibia is the remarkable class of *Mud-fish*, or *Scaly Sirens* (*Dipneusta*, or *Protopteri*). There now exist only a few representatives of this class, namely, the American Mud-fish (*Lepidosiren paradoxa*) in the region of the river Amazon, and the African Mud-fish (*Protopterus annectens*) in different parts of Africa. A third large Salamander-fish (*Ceratodus Fosteri*)

has lately been discovered in Australia. During the dry season, that is in summer, these strange animals bury themselves in a nest of leaves in the dry mud, and then breathe air through lungs like the Amphibia. But during the wet season, in winter, they live in rivers and bogs, and breathe water through gills like fish. Externally, they resemble fish of the eel kind, and are like them covered with scales; in many other characteristics also—in their internal structure, their skeleton, extremities, etc.—they resemble Fish more than Amphibia. But in certain features they resemble the Amphibia, especially in the formation of their lungs, nose, and heart. There is consequently an endless dispute among zoologists, as to whether the Mud-fish are genuine Fish or Amphibia. Distinguished zoologists have expressed themselves in favour of both opinions. But in fact, owing to the complete blending of characteristics which they present, they belong neither to the one nor to the other class, and are probably most correctly dealt with as a special class of Vertebrata, forming the transition between Fishes and Amphibians. The still living Dipneusta are probably the last surviving remains of a group which was formerly rich in forms, but has left no fossil traces on account of the want of a solid skeleton. In this respect, these animals are exactly like the Monorhina and the Leptocardia. However, teeth are found in the Trias which resemble those of the living *Ceratodus*. Possibly the extinct Dipneusta of the palæolithic period, which developed in the Devonian epoch out of primæval fish, must be looked upon as the primary forms of the Amphibia, and thus also of all higher Vertebrata. At all events the unknown forms of transition—from Primæval fish to Amphibia—were probably very like the Dipneusta.

A very peculiar class of Vertebrate animals, long since extinct, and which appears to have lived only during the secondary epoch, is formed by the remarkable *Sea-dragons* (Halisauria, or Enaliosauria, also called Nexipoda, or Swimming-footed animals). These formidable animals of prey inhabited the mesolithic oceans in great numbers, and were of most peculiar forms, sometimes from thirty to forty feet in length. From many and excellently preserved fossil remains and impressions, both of the entire body of Sea-dragons as well as of single parts, we have become very accurately acquainted with the structure of their bodies. They are usually classed among Reptiles, whilst some anatomists have placed them in a much lower rank, as directly allied to Fish. Gegenbaur's recently published investigations, which place the structure of their limbs in a true light, have led to the surprising conclusion that the Sea-dragons form quite an isolated group, differing widely both from Reptiles and Amphibia as well as from Fish. The skeleton of their four legs, which are transformed into short, broad, paddling fins (like those of fish and whales) furnishes us with a clear proof that the Halisauria branched off from the main-stock of Vertebrata at an earlier period than the Amphibia. For Amphibia, as well as the three higher classes of Vertebrata, are all derived from a common primary form, which possessed only *five* toes or fingers on each leg. But the Sea-dragons have (either distinctly developed or in a rudimentary condition as parts of the skeleton of the foot) more than five fingers, as have also the Selachians or Primæval fish. On the other hand, they breathed air through lungs, like the Dipneusta, although they always swam about in the sea. They,

therefore, perhaps, in conjunction with the Dipneusta, branched off from the Selachii, but did not develop into higher Vertebrata; they form an extinct lateral line of the pedigree, which has died out.

The more accurately known Sea-dragons are classed into three orders, distinct enough one from the other, namely, *Primæval Dragons*, *Fish Dragons*, and *Serpent Dragons*. The *Primæval Dragons* (Simosauria) are the oldest Sea-dragons, and lived only during the Trias period. The skeletons of many different genera of them are met with in the German limestone known as "Muschel-kalk." They seem upon the whole to have been very like the Plesiosauria, and are, consequently, sometimes united with them into one order as Sauropterygia. The *Serpent Dragons* (Plesiosauria) lived in the oolitic and chalk periods together with the Ichthyosauria. They were characterised by an uncommonly long thin neck, which was frequently longer than the whole body, and carried a small head with a short snout. When their arched neck was raised they must have looked very like a swan; but in place of wings and legs they had two pairs of short, flat, oval-paddling fins.

The body of the *Fish Dragons* (Ichthyosauria) was of an entirely different form; these animals may be opposed to the two preceding orders under the name of Fish-fanners (Ichthyopterygia). They possessed a very long extended body, like a fish, and a heavy head with an elongated, flat snout, but a very short neck. Externally, they were probably very like porpoises. Their tail was very long, whereas it was very short in the members of the preceding orders. Also both pairs of paddling fins are

broader and show very different structure from that seen in the other two orders. Probably the Fish Dragons and Serpent Dragons developed as two diverging branches out of the Primæval Dragons; but it is also possible that the Plesiosauria alone originated out of the Simosauria, and that the Ichthyosauria were lower off-shoots from the common stock. At all events, they must all be directly, or indirectly derived from the Selachii, or Primæval fish.

The succeeding classes of Vertebrata, the *Amphibia* and the *Amniota* (Reptiles, Birds, and Mammals), owing to the characteristic structure which they all exhibit of five toes to each foot, may all be derived from a common primary form, which originated from the Selachii, and which possessed five toes on each of its four limbs. When we find a less number of toes than five, we can show that the missing ones must have been lost in the course of time by adaptation. The oldest known Vertebrata with five toes are the *Batrachias* (Amphibia). We divide this class into two sub-classes, namely, mailed Batrachians and naked Batrachians, the first of which is distinguished by the body being covered with bony plates or scales.

The first and elder sub-class of Amphibia consists of the *Mailed Batrachians* (Phractamphibia), the oldest land living Vertebrata of which fossil remains exist. Well-preserved fossil remains of them occur in the coal, especially of those with *Enamelled heads* (Ganocephala), which are most closely allied to fish, namely, the *Archegosaurus* of Saarbruck, and the *Dendrerpeton* of North America. There then follow at a later period the gigantic *Labyrinth-toothed animals* (Labyrinthodonta), which are represented in the Permian system by *Zygosaurus*, but at a later

period, more especially in the Trias, by *Mastodonsaurus*, *Trematosaurus*, *Capitosaurus*, etc. The shape of these formidable rapacious animals seems to have been between that of crocodiles, salamanders, and frogs, but in their internal structure they were more closely related to the two latter, while by their solid coat of mail, formed of strong bony plates, they resembled the first animals. These gigantic mailed Batrachians seem to have become extinct towards the end of the Triassic period. No fossil remains of mailed Batrachia are known during the whole of the subsequent periods. However, the still living blind Snakes, or *Cæciliæ* (*Peromela*)—small-scaled *Phractamphibia* of the form and the same mode of life as the earth-worm—prove that this sub-class continued to exist, and never became completely extinct.

The second sub-class of *Amphibia*, the *naked Batrachia* (*Lissamphibia*), probably originated even during the primary and secondary epochs, although fossil remains of them are first found in the tertiary epoch. They are distinguished from mailed Batrachia by possessing a naked smooth, and slimy skin, entirely without scales or coat of mail. They probably developed either out of a branch of the *Phractamphibia*, or out of the same common root with them. The ontogeny of the three still living orders of naked Batrachia—the gilled Batrachia, tailed Batrachia, and frog Batrachia—distinctly repeats the historical course of development of the whole sub-class. The oldest forms are the gilled Batrachia (*Sozobranchia*), which retain throughout life the original primary form of naked Batrachia, and possess a long tail, together with water-breathing gills. They are most closely allied to the *Dipneusta*, from which,

however, they differ externally by the absence of the coat of scales. Most gilled Batrachia live in North America: among others of the class is the Axolotl, or Siredon, already mentioned. (Compare above, vol. i. p. 241.) In Europe the order is only represented by one form, the celebrated "Olm" (*Proteus anguinus*), which inhabits the grotto of Adelsberg and other caves in Carinthia, and which, from living in the dark, has acquired rudimentary eyes which can no longer see (vol. i. p. 13). The order of Tailed Batrachia (*Sozura*) have developed out of the gilled Batrachia by the loss of external gills; the order includes our black and yellow spotted land Salamander (*Salamandra maculata*), and our nimble aquatic Salamanders (*Tritons*). Many of them—for instance, the celebrated giant Salamanders in Japan (*Cryptobranchus Japonicus*)—still retain the gill-slits, although the gills themselves have disappeared. All of them, however, retain the tail throughout life. *Tritons* occasionally — when forced to remain in water always—retain their gills, and thus remain at the same stage of development as gilled Batrachia. (Compare above, vol. i. p. 241.) The third order, the *tailless* or *frog-like Batrachia* (*Anura*), during their metamorphosis, not only lose their gills, with which in early life (as so-called tadpoles) they breathe in water, but also the tail with which they swim about. During their ontogeny, therefore, they pass through the course of development of the whole sub-class, they being at first *Gilled Batrachia*, then *Tailed Batrachia*, and finally *Frog-like Batrachia*. The inference from this is evidently, that *Frog-like Batrachia* developed at a later period out of *Tailed Batrachia*, as the latter had developed out of *Gilled Batrachia* which originally existed alone.

In passing from the Amphibia to the next class of Vertebrata, namely, Reptiles, we observe a very considerable advance in the progress of organization. All the double-nostriled animals (Amphirrhina) up to this time considered, and more especially the two larger classes of Fish and Batrachia, agree in a number of important characteristics, which essentially distinguish them from the three remaining classes of Vertebrata—Reptiles, Birds, and Mammals. During the embryological development of these latter, a peculiarly delicate covering, the *first foetal membrane*, or *amnion*, which commences at the navel, is formed round the embryo; this membrane is filled with the amnion-water, and encloses the embryo or germ in the form of a bladder. On account of this very important and characteristic formation, we may comprise the three most highly developed classes of Vertebrata under the term *Amnion-animals* (Amniota). The four classes of double-nostriled animals which we have just considered, in which the amnion is wanting (as is the case in all lower Vertebrate animals, single-nostriled and skull-less animals), may on the other hand be opposed to the others as *amnion-less animals* (Anamnia).

The formation of the foetal membrane, or amnion, which distinguishes reptiles, birds, and mammals from all other Vertebrata, is evidently a very important process in their ontogeny, and in the phylogeny which corresponds with it. It coincides with a series of other processes, which essentially determine the higher development of Amnionate animals. The first of these important processes is the *total loss of gills*, for which reason the Amniota, under the name of *Gill-less animals* (Ebranchiata), were formerly

opposed to all other Vertebrate animals which breathed through gills (Branchiata). In all the Vertebrata already discussed, we found that they either always breathed through gills, or at least did so in early life, as in the case of Frogs and Salamanders. On the other hand, we never meet with a Reptile, Bird, or Mammal which at any period of its existence breathes through gills, and the gill-arches and openings which do exist in the embryos, are, during the course of the ontogeny, changed into entirely different structures, viz., into parts of the jaw-apparatus and the organ of hearing. (Compare above, vol. i. p. 307.) All Amnionate animals have a so-called cochlea in the organ of hearing, and a "round window" corresponding with it. These parts are wanting in the Amnion-less animals; moreover, their skull lies in a straight line with the axis of the vertebral column. In Amniotic animals the base of the skull appears bent in on the abdominal side, so that the head sinks upon the breast. (Plate III. Fig. *C, D, G, H.*) The organs of tears at the side of the eye also first develop in the Amniota.

The question now is, When did this important advance take place in the course of the organic history of the earth? When did the common ancestor of all Amniota develop out of a branch of the Non-amniota, to wit, out of the branch of the Amphibia?

To this question, the fossil remains of Vertebrata do not give us a very definite, but still they do give an approximate, answer. For with the exception of two lizard-like animals found in the Permian system (the *Proterosaurus* and *Rhopalodon*), all the fossil remains of Amniota, as yet known, belong to the *secondary, tertiary, and quaternary epochs*. With regard to the two Vertebrata

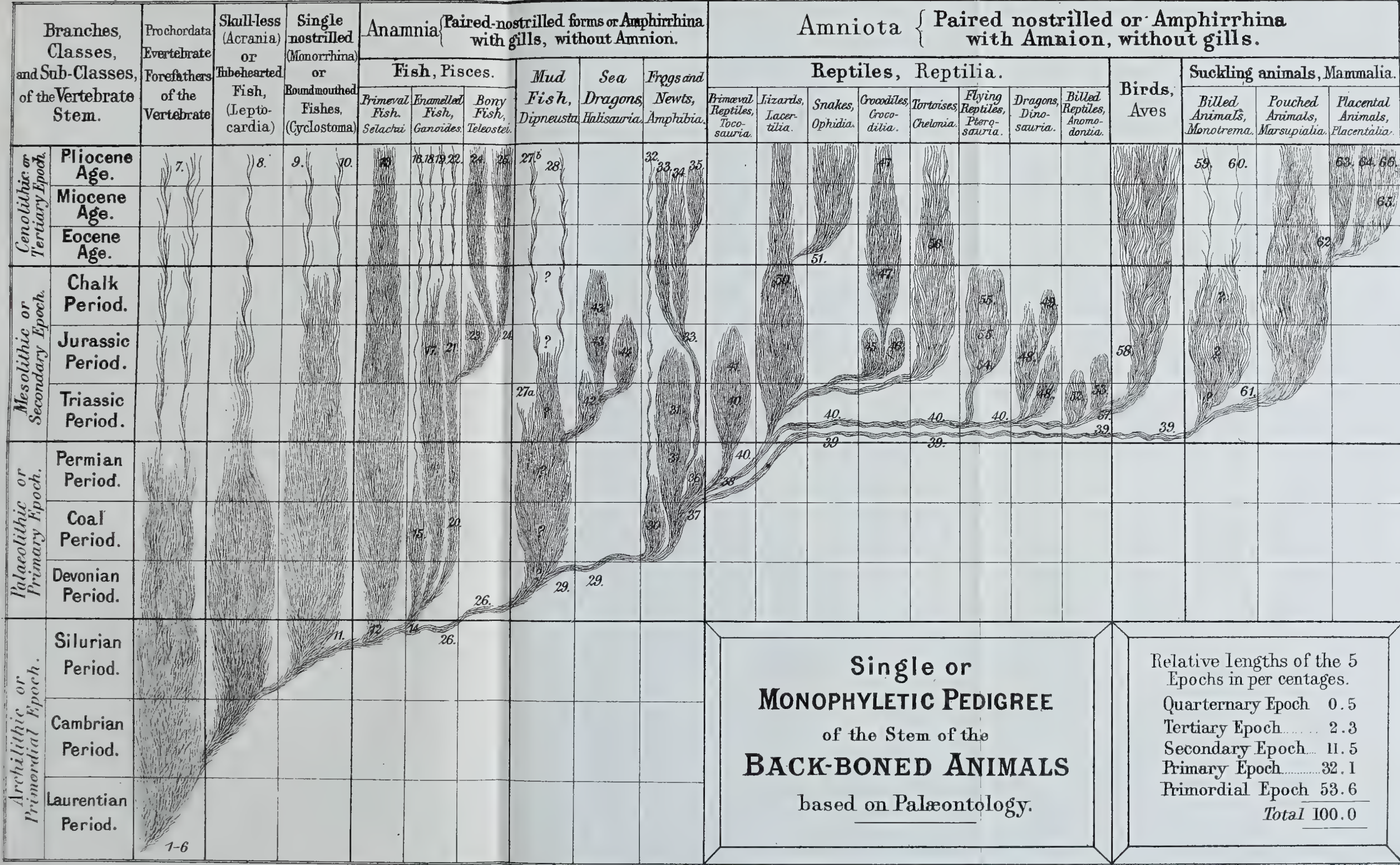
just named, it is still doubtful whether they are genuine reptiles, or perhaps Amphibia of the salamander kind. Their skeleton alone is known to us, and even this not perfectly. Now as we know nothing of the characteristic features of their soft parts, it is quite possible that the *Proterosaurus* and *Rhopalodon* were non-amnionate animals more closely allied to Amphibia than to Reptiles; possibly they belonged to the transition form between the two classes. But, on the other hand, as undoubted fossil remains of Amniota have been found as early as the Trias, it is probable that the *main class of Amniota* first developed in the Trias, that is, in the beginning of the Mesolithic epoch. As we have already seen, this very period is evidently one of the most important turning points in the organic history of the earth. The palæolithic fern forests were then replaced by the pine forests of the Trias period; important transformations then took place in many of the classes of Invertebrata. Articulated marine lilies (*Colocrina*) developed out of the plated ones (*Phatnocrina*.) The *Autechinidæ*, or sea-urchins with only twenty rows of plates, took the place of the palæolithic *Palechinidæ*, the sea-urchins with more than twenty rows of plates. The *Cystideæ*, *Blastoideæ*, *Trilobita*, and other characteristic groups of Invertebrata of the primary period became extinct. It is no wonder that transforming conditions of adaptation powerfully influenced the Vertebrate tribes also in the beginning of the Trias period, and caused the origin of Amniotic animals.

If, however, the two Lizard and Salamander-like animals of the Permian system, the *Proterosaurus* and *Rhopalodon*, are considered genuine Reptiles, and conse-

quently the most ancient Amniota, then the origin of this main class must necessarily have taken place in the preceding period, towards the end of the primary, namely, in the Permian period. However, all other remains of Reptiles, which were formerly believed to have been found in the Permian and the Coal system, or even in the Devonian system, have been proved to be either not remains of Reptiles at all, or to belong to a more recent date (for the most part to the Trias). (Compare Plate XIV.)

The common hypothetical primary form of all Amniotic animals, which we may call *Protamnion*, and which was possibly nearly related to the Proterosaurus, very probably stood upon the whole mid-way between salamanders and lizards, in regard to its bodily formation. Its descendants divided at an early period into two different lines, one of which became the common primary form of Reptiles and Birds, the other the primary form of Mammals.

Of all the three classes of Amniota, *Reptiles* (Reptilia, or Pholidota, also called Sauria in the widest sense), remain at the lowest stage of development, and differ least from their ancestors, the Amphibia. Hence they were formerly universally included among them, although their whole organization is much more like that of Birds than Amphibia. There now exist only four orders of Reptiles, namely,—Lizards, Serpents, Crocodiles, and Tortoises. They, however, form but a poor remnant of the exceedingly various and highly developed host of Reptiles which lived during the Mesolithic, or Secondary epoch, and predominated over all other Vertebrata. The immense development of Reptiles during the Secondary epoch is so characteristic that we could as well name it after those animals as after the



Gymnosperms (p. 111). Twelve of the twenty-seven sub-orders, given on the accompanying table, and four of the eight orders, belong exclusively to the secondary period. These mesolithic groups are marked by an asterisk. All the orders, with the exception of Serpents, are found fossil even in the Jura and Trias periods.

In the first order, that of *Primary Reptiles*, or *Primary Creepers* (Tocosauria), we class the extinct *Thecodontia* of the Trias, together with those Reptiles which we may look upon as the common primary form of the whole class. To the latter, which we may call *Primæval Reptiles* (Proreptilia), the Proterosaurus of the Permian system very probably belongs. The seven remaining orders must be considered as diverging branches, which have developed in different directions out of that common primary form. The *Thecodontia* of the Trias, the only positively known fossil forms of Tocosauria, were Lizards which seem to have been like the still living monitor lizards (Monitor, Varanus).

Of the four orders of reptiles now existing, and which, moreover, have alone represented the class since the beginning of the tertiary epoch, that of *Lizards* (Lacertilia) is probably most closely allied to the extinct Primary Reptiles, and especially through the monitors already named. The class of *Serpents* (Ophidia) developed out of a branch of the order of lizards, and this probably not until the beginning of the tertiary epoch. At least we at present only know of fossil remains of serpents from the tertiary strata. *Crocodiles* (Crocodilia) existed much earlier; the Teleosauria and Steneosauria belonging to the class are found fossil in large quantities even in the Jura; but the

SYSTEMATIC SURVEY

Of the 8 Orders and 27 Sub-orders of Reptiles.

(Those groups marked with * became extinct even during the Secondary Period.)

<i>Orders of Reptiles.</i>	<i>Sub-orders of Reptiles.</i>	<i>Systematic Name of the Sub-orders.</i>	<i>A Generic Name as an example.</i>
I. Primary Reptiles Tocosauria	1. Primæval rep- tiles	1. Proreptilia	* (Proterosaurus†)
	2.	2. Thecodontia	* Palæosaurus
II. Lizards Lacertilia	3. Cleft-tongued	3. Fissilingues	Monitor
	4. Thick-tongued	4. Crassilingues	Iguana
	5. Short-tongued	5. Brevilingues	Anguis
	6. Ringed lizards	6. Glyptodermata	Amphisbæna
	7. Chameleons	7. Vermilingues	Chamæleo
	8. Adders	8. Aglyphodonta	Coluber
III. Serpents Ophidia	9. Tree serpents	9. Opisthoglypha	Dipsas
	10.	10. Proteroglypha	Hydrophis
	11. Vipers	11. Solenoglypha	Vipera
	12. Worm serpents	12. Opoterodonta	Typhlops
IV. Croco- diles Crocodilia	13. Amphicœla	13. Teleosauria	* Teleosaurus
	14. Opisthocœla	14. Steneosauria	* Steneosaurus
	15. Prosthocœla	15. Alligatores	Alligator
V. Tortoises Chelonia	16. Sea tortoises	16. Thalassita	Chelone
	17. River tortoises	17. Potamita	Trionyx
	18. Marsh tortoises	18. Elodita	Emys
	19. Land tortoises	19. Chersita	Testudo
VI. Flying Reptiles Pterosauria *	20. Long-tailed Flying lizards	20. Rhampho- rhynchi	* Rhampho- rhynchus
	21. Short-tailed Flying lizards	21. Pterodactyli	* Pterodactylus
	22. Giant dragons	22. Harpagosauria	* Megalosaurus
VII. Dragons Dinosauria *	23. Elephantine dragons	23. Therosauria	* Iguanodon
VIII. Beaked Reptiles Anomodontia *	24. Dog-toothed	24. Cynodontia	* Dicynodon
	25. Toothless	25. Cryptodontia	* Udenodon
	26. Kangaroo rep- tiles	26. Hypsosauria	* Compsognathus
	27. Bird reptiles	27. Tocornithes	* (Tocornis)

still living alligators are first met with in a fossil state in the chalk and tertiary strata. The most isolated of the four existing orders of reptiles consists of the remarkable group of *Tortoises* (Chelonia); fossils of these strange animals are first met with in the Jura. In some characteristics they are allied to Amphibia, in others, to Crocodiles, and by certain peculiarities even to Birds, so that their true position in the pedigree of Reptiles is probably far down at the root. The extraordinary resemblance of their embryos to Birds, manifested even at later stages of the ontogenesis, is exceedingly striking.

The four extinct orders of Reptiles show among one another, and, with the four existing orders just mentioned, such various and complicated relationships, that in the present state of our knowledge we are obliged to give up the attempt at establishing their pedigree. The most deviating and most curious forms are the *Flying Reptiles* (Pterosauria); flying lizards, in which the extremely elongated fifth finger of the hand served to support an enormous flying membrane. They probably flew about, in the secondary period, much in the same way as the bats of the present day. The smallest flying lizards were about the size of a sparrow; the largest, however, with a breadth of wing of more than sixteen feet, exceeded the largest of our living flying birds in stretch of wing (condor and albatross). Numerous fossil remains of them, of the long-tailed Rhamphorhynchia and of the short-tailed Pterodactylæ are found in all the strata of the Jura and Chalk periods, but in these only.

Not less remarkable and characteristic of the Mesolithic epoch was the group of *Dragons* (Dinosauria, or Pachypoda).

These colossal reptiles, which attained a length of more than fifty feet, are the largest inhabitants of the land which have ever existed on our globe; they lived exclusively in the secondary epoch. Most of their remains are found in the lower cretaceous system, more especially in the Wealden formations of England. The majority of them were fearful beasts of prey (the *Megalosaurus* from twenty to thirty, the *Pelorosaurus* from forty to fifty feet in length). The *Iguanodon*, however, and some others lived on vegetable food, and probably played a part in the forests of the chalk period similar to that of the unwieldy but smaller elephants, hippopotami, and rhinoceroses of the present day.

The *Beaked Reptiles* (*Anomodontia*), likewise also long since extinct, but of which very many remarkable remains are found in the *Trias* and *Jura*, were perhaps closely related to the *Dragons*. Their jaws, like those of most *Flying Reptiles* and *Tortoises*, had become changed into a beak, which either possessed only degenerated rudimentary teeth, or no teeth at all. In this order, if not in the preceding one, we must look for the primary parents of the bird class, which we may call *Bird Reptiles* (*Tocornithes*). Probably very closely related to them was the curious, kangaroo-like *Compsognathus* from the *Jura*, which in very important characteristics already shows an approximation to the structure of birds.

The class of *Birds* (*Aves*), as already remarked, is so closely allied to *Reptiles* in internal structure and by embryonal development, that they undoubtedly originated out of a branch of this class. Even a glance at *Plates II. and III.* will show that the embryos of birds at a time when they already essentially differ from the embryos of

Mammals, are still scarcely distinguishable from those of Tortoises and other Reptiles. The cleavage of the yolk is partial in the case of Birds and Reptiles, in Mammals it is total. The red blood-cells of the former possess a kernel, those of the latter do not. The hair of Mammals develops in closed follicles in the skin, but the feathers of birds and also the scales of reptiles develop in hillocks on the skin. The lower jaw of the latter is much more complicated than that of Mammals; the latter do not possess the quadrate bone of the former. Whereas in Mammals (as in the case of Amphibia) the connection between the skull and the first neck vertebra is formed by two knobbed joints, or condyles, in Birds and Reptiles these have become united into a single condyle. The two last classes may therefore justly be united into one group as Monocondylia, and contrasted to Mammals, or Dicondylia.

The deviation of Birds from Reptiles, in any case, first took place in the mesolithic epoch, and this moreover probably during the Trias. The oldest fossil remains of birds are found in the upper Jura (*Archæopteryx*). But there existed, even in the Trias period, different Saurians (*Anomodontia*) which in many respects seem to form the transition from the *Tocosauria* to the primary ancestors of Birds, the hypothetical *Tocornithes*. Probably these *Tocornithes* were scarcely distinguishable from other beaked lizards in the system, and were closely related to the kangaroo-like *Compsognathus* from the Jura of Solenhofen. Huxley classes the latter with the *Dinosauria*, and believes them to be the nearest relations to the *Tocornithes*.

The great majority of Birds—in spite of all the variety in the colouring of their beautiful feathery dress, and in the

formation of their beaks and feet—are of an exceedingly uniform organization, in much the same way as are the class of insects. The bird form has adapted itself on all sides to the external conditions of existence, without having thereby in any way essentially deviated from the strict hereditary type of its characteristic structure. There are only two small groups, the feather-tailed birds (*Saururæ*) and those of the ostrich kind, which differ considerably from the usual type of bird, namely, from those with keel-shaped breasts (*Carinatae*), and hence the whole class may be divided into three sub-classes.

The first sub-class, the *Reptile-tailed*, or *Feather-tailed Birds* (*Saururæ*), are as yet known only through a single, and that an imperfect, fossil impression, which, however, in being the oldest and also a very peculiar fossil bird, is of great importance. This fossil is the *Primæval Griffin*, or *Archæopteryx lithographica*, of which as yet only one specimen has been found in the lithographic slate at Solenhofen. in the Upper Jura system of Bavaria. This remarkable bird seems on the whole to have been of the size and form of a large raven, especially as regards the legs, which are in a good state of preservation; head and breast unfortunately are wanting. The formation of the wings deviates somewhat from that of other birds, but that of the tail still more so. In all other birds the tail is very short and composed of but few short vertebræ; the last of these have grown together into a thin, bony plate standing perpendicularly, upon which the rudder-feathers of the tail are attached in the form of a fan. The *Archæopteryx*, however, has a long tail like a lizard, composed of numerous (20) long thin vertebræ, and on every vertebra are attached the

strong rudder-feathers in twos, so that the whole tail appears regularly feathered. This same formation of the tail part of the vertebral column occurs transiently in the embryos of other birds, so that the tail of the Archæopteryx evidently represents the original form of bird-tail inherited from reptiles. Large numbers of similar birds with lizard-tails probably lived during the middle of the secondary period; accident has as yet, however, only revealed this one fossil.

The *Fan-tailed*, or *Keel-breasted birds* (Carinatae), which form the second sub-class, comprise all living Birds of the present day, with the exception of those of the ostrich kind, or Ratitæ. They probably developed out of Feather-tailed Birds during the first half of the secondary period, namely, in the Jura or chalk period, by the hinder tail vertebræ growing together, and by the tail becoming shortened. Only very few remains of them are known from the secondary period, and these moreover only out of the last section of it, namely, from the Chalk. These remains belong to a swimming bird of the albatross species, and a wading bird like a snipe. All the other fossil remains of birds as yet known have been found in the tertiary strata.

The *Bushy-tailed*, or *Ostrich-like Birds* (Ratitæ), also called *Running Birds* (Cursores), the third and last sub-class, is now represented only by a few living species, by the African ostrich with two toes, the American and Australian ostrich with three toes, by the Indian cassowary and the four-toed kiwi, or Apteryx, in New Zealand. The extinct giant birds of Madagascar (Æpyornis) and the New Zealand Dinornis, which were much larger than the

still living ostriches, also belong to this group. The Birds of the ostrich kind—by giving up the habit of flying, by the degeneration of the muscles for flying resulting from this, and of the breast bone which serves as their support, and by the corresponding stronger development of the hinder legs for running—have probably arisen out of a branch of the Keel-breasted birds. But possibly, as Huxley thinks, they may be the nearest relations of the Dinosauria and of the Reptiles akin to them, especially of the *Compsognathus*; at all events, the common primary form of all Birds must be looked for among the extinct Reptiles.

CHAPTER XXI.

PEDIGREE AND HISTORY OF THE ANIMAL KINGDOM.

IV. MAMMALS.

The System of Mammals according to Linnæus and Blainville.—Three Sub-classes of Mammals (Ornithodelphia, Didelphia, Monodelphia).—Ornithodelphia, or Monotrema.—Beaked Animals (Ornithostoma).—Didelphia, or Marsupials.—Herbivorous and Carnivorous Marsupials.—Monodelphia, or Placentalia (Placental Animals).—Meaning of the Placenta.—Tuft Placentalia.—Girdle Placentalia.—Disc Placentalia.—Non-deciduates, or Indeciduate.—Hoofed Animals.—Single and Double-hoofed Animals.—Whales.—Toothless Animals.—Deciduates, or Animals with Decidua.—Semi-apes.—Gnawing Animals.—Pseudo-hoofed Animals.—Insectivora.—Beasts of Prey.—Bats.—Apes.

THERE are only a few points in the classification of organisms upon which naturalists have always agreed. One of these few undisputed points is the privileged position of the class of Mammals at the head of the animal kingdom. The reason of this privilege consists partly in the special interest, also in the various uses and the many pleasures, which Mammals, more than all other animals, offer to man, and partly in the circumstance that man himself is a member of this class. For however differently in other respects man's position in nature and in the system of animals may have been regarded, yet no naturalist has ever doubted that man, at least from a purely

morphological point of view, belongs to the class of Mammals. From this there directly follows the exceedingly important inference that man, by consanguinity also, is a member of this class of animals, and has historically developed out of long since extinct forms of Mammals. This circumstance alone justifies us here in turning our especial attention to the history and the pedigree of Mammals. Let us, therefore, for this purpose first examine the groups of this class of animals.

Older naturalists, especially considering the formation of the jaw and feet, divided the class of Mammals into a series of from eight to sixteen orders. The lowest stage of the series was occupied by the whales, which seemed to differ most from man, who stands at the highest stage, by their fish-like form of body. Thus Linnæus distinguished the following eight orders: (1) *Cetæ* (whales); (2) *Belluæ* (hippopotami and horses); (3) *Pecora* (ruminating animals); (4) *Glires* (gnawing animals and rhinoceroses); (5) *Bestiæ* (insectivora, marsupials, and various others); (6) *Feræ* (beasts of prey); (7) *Bruta* (toothless animals and elephants); (8) *Primates* (bats, semi-apes, apes, and men). Cuvier's classification, which became the standard of most subsequent zoologists, did not rise much above that of Linnæus. Cuvier distinguished the following eight orders: (1) *Cetacea* (whales); (2) *Ruminantia* (ruminating animals); (3) *Pachyderma* (hoofed animals, with the exclusion of ruminating animals); (4) *Edentata* (animals poor in teeth); (5) *Rodentia* (gnawing animals); (6) *Carnassia* (marsupials, beasts of prey, insectivora, and bats); (7) *Quadrumana* (semi-apes and apes); (8) *Bimana* (man).

The most important advance in the classification of

Mammals was made as early as 1816 by the eminent anatomist Blainville, who has already been mentioned, and who first clearly recognised the three natural main groups or sub-classes of Mammals, and distinguished them according to the formation of their generative organs as *Ornithodelphia*, *Didelphia*, and *Monodelphia*. As this division is now justly considered by all scientific zoologists to be the best, on account of solid foundation on the history of development, let us here keep to it also.

The first sub-class consists of the *Cloacal Animals*, or *Breastless animals*, also called *Forked animals* (Monotrema, or Ornithodelphia). This class is now represented only by two species of living mammals, both of which are confined to Australia and the neighbouring island of Van Diemen's land, namely, the well-known Water Duck-bill (*Ornithorhynchus paradoxus*) with the beak of a bird, and the less known Beaked Mole (*Echidna hystrix*), resembling a hedgehog. Both of these curious animals, which are classed in the order of *Beaked Animals* (Ornithostoma), are evidently the last surviving remnants of an animal group formerly rich in forms, which alone represented the Mammalia in the secondary epoch, and out of which the second sub-class, the *Didelphia*, developed later, probably in the Jurassic period. Unfortunately, we as yet do not know with certainty of any fossil remains of this most ancient primary group of Mammals, which we will call *Primary Mammals* (Pro-mammalia). Yet they possibly comprise the oldest of all the fossil Mammalia known, namely, the *Microlestes antiquus*, of which animals, however, we as yet only know some few small molar teeth. These have been found in the uppermost strata of the Trias, in the Keuper, first in Ger-

many (at Degerloch, near Stuttgart, in 1847), later also in England (at Frome), in 1858. Similar teeth have lately been found also in the North American Trias, and have been described as *Dromatherium sylvestre*. These remarkable teeth, from the characteristic form of which we can conclude that they belonged to an insectivorous mammal, are the only remains of mammals as yet found in the older secondary strata, namely, in the Trias. It is possible, however, that besides these many of the other mammalian teeth found in the Jura and Chalk systems, which are still generally ascribed to Marsupials, in reality belong to Cloacal Animals. This cannot be decided with certainty owing to the absence of the characteristic soft parts. In any case, numerous Monotrema, with well-developed teeth and cloaca, must have preceded the advent of Marsupial animals.

The designation, "*Cloacal animals*" (Monotrema), has been given to the Ornithodelphia on account of the cloaca which distinguishes them from all other Mammals; but which on the other hand makes them agree with Birds, Reptiles, and Amphibia, in fact, with the lower Vertebrata. The formation of the cloaca consists in the last portion of the intestinal canal receiving the mouth of the urogenital apparatus, that is, the united urinary and genital organs, whereas in all other Mammals (Didelphia as well Monodelphia) these organs have an opening distinct from that of the rectum. However, in these latter also the cloaca formation exists during the first period of their embryonal life, and the separation of the two openings takes place only at a later date (in man about the twelfth week of development). The Cloacal animals have also been called "*Forked animals*," because the collar-bones, by means of the breast

bone, have become united into one piece, similar to the well-known fork-bone, or merry-thought, in birds. In all other Mammals the two collar-bones remain separated in front and do not fuse with the breast bone. Moreover, the coracoid bones are much more strongly developed in the Cloacal animals than in the other Mammalia, and are connected with the breast bone.

In many other characteristics also—especially in the formation of their internal genital organs, their auricular labyrinth, and their brain—Beaked animals are more closely allied to the other Vertebrata than to Mammals, so that some naturalists have been inclined to separate them from the latter as a special class. However, like all other Mammals, they bring forth living young ones, which for a time are nourished with milk from the mother. But whereas in all other Mammals the milk issues through nipples, or teats, from the mammary glands, teats are completely wanting in beaked animals, and the milk comes simply out of a flat, sieve-like, perforated patch of the skin. Hence they may also be called *Breastless* or *Teatless animals* (Amasta).

The curious formation of the beak in the two still living Beaked animals, which is connected with the suppression of the teeth, must evidently not be looked upon as an essential feature of the whole sub-class of Cloacal animals, but as an accidental character of adaptation distinguishing the last remnant of the class as much from the extinct main group, as the formation of a similar toothless snout distinguishes many toothless animals (for instance, the ant-eater) from the other placental animals. The unknown, extinct Primary Mammals, or Promammalia—which lived during the Trias period, and of which the two still living

orders of Beaked animals represent but a single degenerated branch developed on one side—probably possessed a very highly developed jaw like the marsupial animals, which developed from them.

Marsupial, or *Pouched Animals* (Didelphia, or Marsupialia), the second of the three sub-classes of Mammals, form in every respect—both as regards their anatomy and embryology, as well as their genealogy and history—the transition between the other sub-classes—the Cloacal and Placental Animals. Numerous representatives of this group still exist, especially the well-known kangaroos, pouched rats, and pouched dogs; but on the whole this sub-class, like the preceding one, is evidently approaching its complete extinction, and the living members of the class are the last surviving remnants of a large group rich in forms, which represented the Mammalia during the more recent secondary and the earlier tertiary periods. The Marsupial Animals probably developed towards the middle of the Mesolithic epoch (during the Jura) out of a branch of the Cloacal Animals, and in the beginning of the Tertiary epoch again, the group of Placental Animals arose out of the Marsupials, and the latter then succumbed to the former in the struggle for life. All the fossil remains of Mammals known to us from the Secondary epoch, belong either exclusively to Marsupials, or partly perhaps to Cloacal animals. At that time Marsupials seem to have been distributed over the whole earth; even in Europe (France and England), well-preserved fossil remains of them have been found. On the other hand, the last off-shoots of the sub-class now living are confined to a very narrow tract of distribution, namely, to Australia, the Australasian, and a small part of the Asiatic, Archipelago.

There are also a few species still living in America, but at the present day not a single marsupial animal lives on the continent of Asia, Africa, or Europe.

The name of pouched animals is given to the class on account of the purse-shaped pouch (marsupium) existing in most instances on the abdominal side of the female animals, in which the mother carries about her young for a considerable time after their birth. This pouch is supported by two characteristic marsupial bones, also existing in Cloacal animals, but not in Placental animals. The young Marsupial animal is born in a much more imperfect form than the young Placental animal, and only attains the same degree of development which the latter possesses directly at its birth, after it has developed in the pouch for some time. In the case of the giant kangaroo, which attains the height of a man, the newly born young one, which has been carried in the maternal womb not much longer than five weeks, is not more than an inch in length, and only attains its essential development subsequently, in the pouch of the mother, where it remains about nine months attached to the nipple of the mammary gland.

The different divisions generally distinguished as families in the sub-class of Marsupial animals, deserve in reality the rank of independent orders, for they differ from one another in manifold differentiations of the jaw and limbs, in much the same manner, although not so sharply, as the various orders of Placental animals. In part they perfectly agree with the latter. It is evident that adaptation to similar conditions of life has effected entirely coincident or analogous transformations of the original fundamental form

in the two sub-classes of Marsupials. According to this, about eight orders of Marsupial animals may be distinguished, the one half of the main group or legion of which are herbivorous, the other half carnivorous. The oldest fossil remains of the two legions (if the previously mentioned *Microlestes* and the *Dromatherium* are not included) occur in the Jurassic strata, namely, in the slates of Stonesfield, near Oxford. The slates belong to the Bath, or the Lower Oolite formation—strata which lie directly above the Lias, the oldest Jura formation. (Compare p. 15). It is true that the remains of Marsupials found in the slates of Stonesfield, as well as those which were found later in the Purbeck strata, consist only of lower jaws. (Compare p. 29.) But fortunately the lower jaw is just one of the most characteristic parts of the skeleton of Marsupials. For it is distinguished by a hook-shaped process of the lower corner of the jaw turning downwards and backwards, which neither occurs in Placental nor in the (still living) Cloacal animals, and from the existence of this process on the lower jaws from Stonesfield, we may infer that they belonged to Marsupials.

Of *Herbivorous marsupials* (*Botanophaga*), only two fossils are as yet known from the Jura, namely, the *Stereognathus ooliticus*, from the slates of Stonesfield (Lower Oolite), and the *Plagiaulax Becklesii*, from the middle Purbeck strata (Upper Oolite). But in Australia there are gigantic fossil remains of extinct herbivorous Marsupials from the diluvial period (*Diprotodon* and *Nototherium*) which were far larger than the largest of the still living Marsupials. The *Diprotodon Australis*, whose skull alone is three feet long, exceeded even the river-horse, or *Hippopotamus*, in size and upon the

SYSTEMATIC SURVEY OF CLOACAL AND MARSUPIAL MAMMALIA.

I. First Sub-class of Mammalia :

Forked or Cloacal Animals (Monotrema, or Ornithodelphia).

Mammals with Cloaca, without Placenta, with Marsupial Bones.

I. Primary Mammals Promammalia	}	Unknown extinct Mammalia from the Trias Period			(Microlestes ?) (Dromatherium ?)
II. Beaked Animals Ornithostoma		1. Aquatic beaked animals	1. Ornithorhynchida	1. Ornithorhynchus paradoxus	
		2. Terrestrial beaked animals	2. Echidnida	2. Echidna hystrix	

II. Second Sub-class of Mammalia :

Pouched or Marsupial Animals (Marsupialia, or Didelphia).

Mammals without Cloaca, without Placenta, with Marsupial Bones.

<i>Legions of Marsupialia.</i>	<i>Orders of Marsupialia.</i>	<i>Systematic Name of the Orders.</i>	<i>Families of the Marsupialia.</i>
III. Herbivorous Marsupial Animals Marsupialia Botanophaga	1. Hoofed Marsupial animals	1. Barypoda	{ 1. Stereognathida 2. Nototherida 3. Diprotodontia
	2. Kangaroo Marsupial animals (Leaping pouched animals)	2. Macropoda	{ 4. Plagiulacida 5. Halmaturida 6. Dendrolagida
	3. Root-eating Marsupial animals (Gnawing pouched animals)	3. Rhizophaga	{ 7. Phascolomyida
	4. Fruit eating Marsupial animals (Climbing pouched animals)	4. Carpophaga	{ 8. Phascolaretida 9. Phalangistida 10. Petaurida
IV. Carnivorous Marsupial Animals Marsupialia Zoophaga	5. Insectivorous Marsupial animals (Primæval pouched animals)	5. Cantharophaga	{ 11. Thylacotherida 12. Spalacotherida 13. Myrmecobida 14. Peramelida
	6. Marsupial animals poor in teeth (Pouched animals with trunks)	6. Edentula	{ 15. Tarsipedina
	7. Rapacious marsupial animals (Rapacious pouched animals)	7. Creophaga	{ 16. Dasyurida 17. Thylacinida 18. Thylacoleonida
	8. Ape-footed Marsupial animals (Pouched animals with hands)	8. Pedimana	{ 19. Chironectida 20. Didelphyida

SYSTEMATIC SURVEY OF PLACENTAL ANIMALS.

III. Third Sub-class of Mammalia ;

Placentalia, or Monodelphia (Placental Animals).

Mammals without Cloaca, with Placenta, without Marsupial Bones.

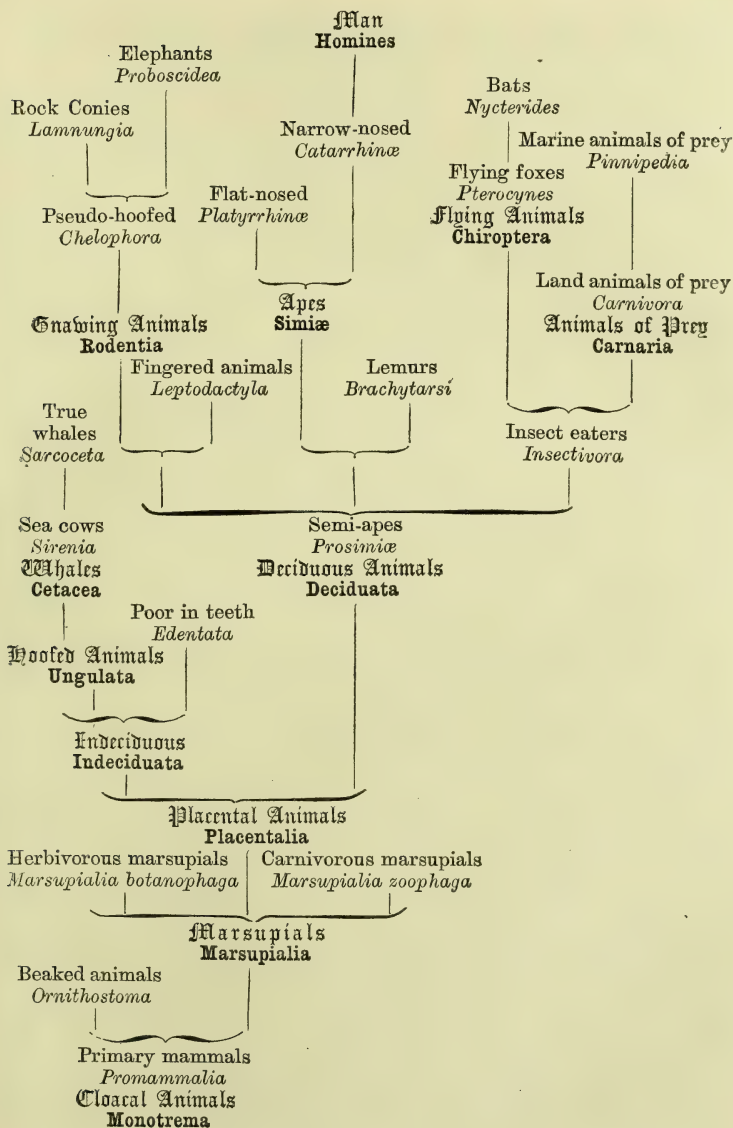
<i>Legions of the Placental Animals.</i>	<i>Orders of the Placental Animals.</i>	<i>Sub-orders of the Placental Animals.</i>	<i>Systematic Name of the Sub-orders.</i>
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III. 1. INDECIDUA. *Placental Animals without Decidua.*

V. Hoofed Animals Ungulata	I. Single-hoofed <i>Perissodactyla</i>	1. Tapirs	1. Tapiromorpha
	II. Double-hoofed <i>Artiodactyla</i>	2. Horses	2. Solidungula
		3. Pigs	3. Choeromorpha
		4. Ruminating	4. Ruminantia
VI. Whales Cetacea	III. Herbivorous Whales <i>Phycoceta</i>	5. Sea cows	5. Sirenia
	IV. Carnivorous Whales <i>Sarcoceta</i>	6. Whales	6. Autoceta
		7. Zeuglodonta	7. Zeugloceta
VII. Animals poor in teeth Edentata	V. Digging Animals <i>Effodientia</i>	8. Ant-eaters	8. Vermilinguia
	VI. Sloths <i>Bradypoda</i>	9. Armadilloes	9. Cingulata
		10. Giant Sloths	10. Gravigrada
		11. Dwarf Sloths	11. Tardigrada

III. 2. DECIDUATA. *Placental Animals with Decidua.*

VIII. Placental Ani- mals. Zonoplacentalia	VII. Rapacious Animals <i>Carnaria</i>	12. Rapacious land animals	12. Carnivora
	VIII. False-hoofed Animals <i>Chetophora</i>	13. Rapacious sea animals	13. Pinnipedia
		14. Hyrax	14. Lamnungia
		15. Toxodonts	15. Toxodontia
		16. Dinotheria	16. Gonyognathia
		17. Elephants	17. Proboscidea
XI. Disc Placental Animals Discoplacentalia	IX. Semi-apes <i>Prosimia</i>	18. Fingered ani- mals	18. Leptodactyla
	X. Gnawing Ani- mals <i>Rodentia</i>	19. Flying lemur	19. Ptenopleura
		20. Long-footed	20. Macrotarsi
		21. Short-footed	21. Brachytarsi
		22. Squirrel species	22. Sciuromorpha
		23. Mouse species	23. Myomorpha
		24. Porcupine spe- cies	24. Hystriehomorpha
		25. Hare species	25. Lagomorpha
		26. With a Cæcum	26. Menotyphla
		27. Without a Cæ- cum	27. Lipotyphla
	XI. Insect-eating Animals <i>Insectivora</i>	28. Flying foxes	28. Pterocynes
	XII. Flying Animals <i>Chiroptera</i>	29. Bats	29. Nycterides
		30. Clawed apes	30. Arctopithecii
	XIII. Apes <i>Simia</i>	31. Flat-nosed	31. Platyrrhinæ
		32. Narrow-nosed	32. Catarrhinæ



whole resembled it in the unwieldy and clumsy form of body. This extinct group, which probably corresponded with the gigantic placental hoofed animals of the present day—the hippopotami and rhinoceroses—may be called Hoofed Marsupials (Barypoda). Closely allied to them is the order of kangaroos, or Leaping Marsupials (Macropoda), which all have seen in zoological gardens. In their shortened fore legs, their very lengthened hind legs, and very strong tail, which serves as a jumping pole, they correspond with the leaping mice in the class of Rodents. Their jaw, however, resembles that of horses, and their complex stomach that of Ruminants. A third order of Herbivorous Marsupials corresponds in its jaws to Rodents, and in its subterranean mode of life, especially, to digging mice. Hence they may be termed Rodent Marsupials, or root-eating pouched animals (Rhizophaga). They are now represented only by the Australian wombat (Phascolomys). A fourth and last order of Herbivorous Marsupials is formed by the climbing or Fruit-eating Marsupials (Carpophaga), whose mode of life and structure resembles partly that of squirrels, partly that of apes (Phalangista, Phascolarctus).

The second legion of Marsupials, the *Carnivorous Marsupials* (Zoophaga), is likewise divided into four main groups or orders. The most ancient of these is that of the primæval, or Insectivorous Marsupials (Cantharophaga). It probably includes the primary forms of the whole legion, and possibly also those of the whole sub-class. At least, all the lower jaws from Stonesfield (with the exception of the *Stereognathus*) belong to Insectivorous Marsupials, and the still living *Myrmecobius* is their nearest relative. But some of those oolitic Primæval Marsupials possessed a larger

number of teeth than all the other known mammals, for each half of the lower jaw of the *Thylacotherium* contained sixteen teeth (three incisors, one canine tooth, six pseudo, and six genuine molars). If the upper jaw, which is unknown, had as many teeth, then the *Thylacotherium* had no less than sixty-four teeth, just double the number possessed by man. The Primæval Marsupials correspond, on the whole, with the Insectivora among Placental animals, which order includes hedgehogs, moles, and shrew-mice. A second order, which has probably developed out of a branch of the last, consists of the Snouted, or Toothless Marsupials (*Edentula*), which resemble the Toothless animals, or *Edentata*, among the Placental animals by their tube-shaped snout, their degenerated jaws, and their corresponding mode of life. On the other hand, the mode of life and formation of the jaws of Rapacious marsupials (*Creophaga*) correspond with those of the genuine Beasts of Prey, or *Carnivora*, among Placental animals. This order includes the pouched marten (*Dasyurus*) and the pouched wolf (*Thylacinus*) in Australia. Although the latter attains to the size of a wolf, it is but a dwarf in comparison with the extinct Australian pouched lions (*Thylacoleo*) which were at least as large as a lion, and possessed huge canine teeth more than two inches in length. Finally, the eighth and last order is formed by the marsupials with hands, or the Ape-footed Pouched animals (*Pedimana*), which live both in Australia and America. They are frequently kept in zoological gardens, especially the different species of the genus *Didelphys*, and are known by the name of pouched rats, bush rats, or opossums. The thumb on their hinder feet is opposable to the four other toes, as in a hand, and by this they are

directly allied to the Semi-apes, or Prosimia, among Placental animals. It is possible that these latter are really next akin to the marsupials with hands, and that they have developed out of their long since extinct ancestors.

It is very difficult to discover the genealogy of Marsupials, and this more especially because we are but very imperfectly acquainted with the whole sub-class; and the Marsupials of the present day are evidently only the last remnants of a group that was at one time rich in forms. It is possible that Marsupials with hands, those with snouts, as well as rapacious Marsupials, developed as three diverging branches out of the common primary group of Primæval Marsupials. In a similar manner, on the other hand, the rodent, leaping, and hoofed Marsupials have perhaps arisen as three diverging branches out of the common herbivorous primary group, that is, out of the Climbing Marsupials. Climbing and Primæval Marsupials might, however, be two diverging branches of the common primary forms of all Marsupials, that is, of the *Primary Marsupials* (Prodidelphia), which originated during the older secondary period out of Cloacal animals.

The third and last sub-class of mammals comprises the *Placental animals*, or *Placentals* (Monodelphia, or Placentalia). It is by far the most important, comprehensive, and most perfect of the three sub-classes; for the class includes all the known mammalia, with the exception of Marsupials and Beaked animals. Man also belongs to this sub-class, and has developed out of its lower members.

Placental animals, as their name indicates, are distinguished from all other mammals, more especially by the formation of a so called *placenta*. This is a very peculiar

and remarkable organ, which plays an exceedingly important part in nourishing the young one developing in the maternal body. The placenta (also called after-birth) is a soft, spongy, red body, which differs very much in form and size, but which consists for the most part of an intricate network of veins and blood vessels. Its importance lies in the exchange of substance between the nutritive blood of the maternal womb, or uterus, and the body of the germ, or embryo. (See vol. i. p. 298). This very important organ is developed neither in marsupials nor in beaked animals. But placental animals are also distinguished from these two sub-classes by many other peculiarities, thus more especially by the absence of marsupial bones, by the higher development of the internal sexual organs, and by the more perfect development of the brain, especially of the so-called callous body or beam (*corpus callosum*), which, as the intermediate commissure, or transverse bridge, connects the two hemispheres of the large brain with each other. Placental animals also do not possess the peculiar hooked process of the lower jaw which characterizes Marsupials. The following classification (p. 246) of the most important characteristics of the three sub-classes will best explain how Marsupials, in these anatomical respects, stand midway between Cloacal and Placental animals.

Placental animals are more variously differentiated and perfected, and this, moreover, in a far higher degree, than Marsupials, and they have, on this account, long since been arranged into a number of orders, differing principally in the formation of the jaws and feet. But what is even of more importance than these, is the different development of the placenta, and the manner of its connection with the

maternal uterus. For in the three lower orders of Placental animals, in Hoofed animals, Whales, and Toothless animals, the peculiar spongy membrane, which is called the *deciduous membrane*, or *decidua*, and which connects the maternal and the foetal portions of the placenta, does *not* become developed. This takes place exclusively in the seven higher orders of Placental animals, and we may, therefore, according

Three Sub-Classes of Mammals.	Cloacal Animals MONOTREMA or ORNITHODEL- PHIA	Pouched Animals MARSUPIALIA or DIDELPHIA	Placental Animals PLACENTALIA or MONODELPHIA
1. Cloaca formation	Constant	Embryonal	Embryonal
2. Nipples of the pec- toral glands, or milk warts	Wanting	Existing	Existing
3. Fore collar bones, or clavicles, grown to- gether in the middle, with the breast bone, and forming a forked bone	United	Not united	Not united
4. Marsupial bones	Existing	Existing	Wanting
5. <i>Corpus callosum</i> of the brain	Feebly developed	Feebly developed	Strongly developed
6. Placenta	Wanting	Wanting	Existing

to Huxley, class them in the main group of *Deciduata*, or animals with *decidua*. They are contrasted with the three first-mentioned legions of indeciduous animals, or *Indeciduata*.

But in the various orders of Placental animals the placenta differs not only in important internal differences of structure, which are connected with the absence or the presence

of a decidua, but also in the external form of the placenta itself. In the *Indeciduata* it consists, in most cases, of numerous, single, scattered bunches or tufts of vessels, and hence this group may be called *tufted placental animals*, (*Villi-placentalia*). In the *Deciduata*, however, the single tufts of vessels are united into a cake, which appears in two different forms. In the one case it surrounds the embryo in the form of a closed band or ring, so that only the two poles of the oval egg bladder are free of tufts; this is the case in animals of prey (*Carnaria*) and the pseudo-hoofed animals (*Chelophora*), which may consequently be comprised as *girdled-placental animals* (*Zonoplacentalia*). In the other *Deciduata*, to which man also belongs, the placenta is a simple round disc, and we therefore call them *disc-placentals* (*Discoplacentalia*). This group includes the five orders of Semi-apes, Gnawing animals, Insectivora, Bats, and Apes, from the latter of which, in the zoological system, man cannot be separated.

It may be considered as quite certain, from reasons based upon their comparative anatomy and their history of development, that Placental animals first developed out of Marsupials, and that this very important development—the first origin of the placenta—probably took place in the beginning of the tertiary epoch, during the eocene period. But one of the most difficult questions in the genealogy of animals is the important consideration whether all Placental animals have arisen out of one or out of several distinct branches of Marsupials; in other words, whether the origin of the placenta occurred but once, or several times.

When, in my *General Morphology*, I for the first time endeavoured to establish the pedigree of Mammals, I here,

as in most cases, preferred the monophyletic, or one-rooted, to the polyphyletic, or many-rooted, hypothesis of descent. I assumed that all Placental animals were derived from a single form of Marsupial animal, which, for the first time, began to form a placenta. In this case the Villiplacentals, Zonoplacentals, and Discoplacentals would perhaps have to be considered as three diverging branches of the common primary form of Placentals, or it might also be conceived that the two latter, the Deciduata, had developed only at a later period out of the Indeciduata, which on their part had arisen directly out of the Marsupials. However, there are also important reasons for the alternative; namely, that several groups of Placentals, differing from the beginning, arose out of several distinct groups of Marsupials, so that the placenta itself was formed several times independently. This opinion is maintained by Huxley, the most eminent English zoologist, and by many others. In this case the Indeciduata and the Deciduata would perhaps have to be considered as two completely distinct groups; then the order of Hoofed animals, as the primary group of the Indeciduata, might be supposed to have originated out of the Marsupial hoofed animals (Barypoda). Among the Deciduata, on the other hand, the order of Semi-apes, as the common primary form of the other orders, might possibly have arisen out of Handed Marsupials (Pedinana). But it is also conceivable that the Deciduata themselves have arisen out of several different orders of Marsupials, Animals of Prey out of Rapacious Marsupials, Gnawing animals out of Gnawing Marsupials, Semi-apes out of Handed Marsupials, etc. As we do not at present possess sufficient empiric material to solve this most difficult question, we must leave it and

turn our attention to the history of the different orders of Placental animals, whose pedigree can often be very accurately established in detail.

We must, as already remarked, consider the order of *Hoofed animals* (Ungulata) as the primary group of the Indeciduata, or Tuft-placentals; the two other orders, Whales and Toothless animals, developed out of them, as two diverging groups, probably only at a later period, by adaptation to very different modes of life. But it is also possible that the animals poor in teeth (Edentata) may be of quite a different origin.

Hoofed animals are in many respects among the most important and the most interesting Mammals. They distinctly show that a true understanding of the natural relationship of animals can never be revealed to us merely by the study of living forms, but in all cases only by an equal consideration of their extinct and fossil blood-relations and ancestors. If, as is usually done, only the living Hoofed animals are taken into consideration, it seems quite natural to divide them into three entirely distinct orders, namely: (1) Horses, or *Single-hoofed animals* (Solidungula, or Equina); (2) Ruminating animals, or *Double-hoofed* (Bisulca, or Ruminantia); and (3) Thick-skinned, or *Many-hoofed* (Multungula, or Pachyderma). But as soon as the extinct Hoofed animals of the tertiary period are taken into consideration—of which animals we possess very numerous and important remains—it is seen that this division, but more especially the limitation of the Thick-skinned animals, is completely artificial, and that these three groups are merely top branches lopped from the pedigree of Hoofed animals, which are most closely connected by extinct intermediate forms. The one

half of the Thick-skinned animals—rhinoceroses, tapirs, and palæotheria—manifest the closest relationships to horses, and have like them odd-toed feet; whereas the other half of the Thick-skinned animals—pigs, hippopotami, and anoplotheria—on account of their double-toed feet are much more closely allied to ruminating animals than to the former. Hence we must, in the first place, among Hoofed animals distinguish the two orders of Paired-hoofs and Odd-hoofs, as two natural groups, which developed as diverging branches out of the old tertiary primary group of Primary Hoofed animals, or Prochela.

The order of *Odd-hoofed animals* (Perissodactyla) comprises those Ungulata in which the middle (or third) toe of the foot is much more strongly developed than the others, so that it forms the actual centre of the hoof. This order includes the very ancient, common, primary group of all Hoofed animals, that is, the *Primary-hoofed animals* (Prochela), which are found in a fossil state in the oldest Eocene strata (Lophiodon, Coryphodon, Pliolophus). Directly allied to this group is that branch which is the actual primary form of the Odd-hoofed animals, namely, the *Palæotheria*, fossils of which occur in the upper Eocene and lower Miocene. Out of the Palæotheria, at a later period, the rhinoceroses (Nasicornia) and rhinoceros-horses (Elasmotherida) on the one hand, and the tapirs, lama-tapirs, and primæval horses, on the other, developed as two diverging branches. The long since extinct primæval horses, or Anchitheria, formed the transition from the Palæotheria and tapirs to the Miocene horses, or hipparions, which are closely allied to the genuine living horses.

The second main group of Hoofed animals, the order of

Pair-hoofed animals (Artiodactyla), comprises those hoofed animals in which the middle (third) and fourth toe of the foot are almost equally developed, so that the space between the two forms the central line of the entire foot. The order is divided into two sub-orders—the Pig-shaped and the Cud-chewing, or Ruminating. The *Pig-shaped* (Chœromorpha) comprise in the first place the other branch of Primary-Hoofed-animals, the *Anoplotheria*, which we consider as the common primary form of all Pair-hoofed animals, or Artiodactyla (Dichobune, etc.) Out of the *Anoplotheria* arose, as two diverging branches, the primæval swine, or *Anthraco-theria*, on the one hand, forming the transition to swine and river-horses, and the *Xiphodonta* on the other hand, forming the transition to Ruminating animals. The oldest *Ruminating animals* (Ruminantia) are the Primæval Stags, or *Dremotheria*, out of which, possibly, the stag-shaped (*Elaphia*), the hollow-horned (*Cavicornia*), and camels (*Tylopoda*), have developed as three diverging branches. Yet these latter are, in many respects, more allied to the Odd-hoofs than to the genuine Pair-hoofs. The accompanying systematic survey on p. 252, will show how the numerous families of Hoofed animals are grouped, in correspondence with this genealogical hypothesis.

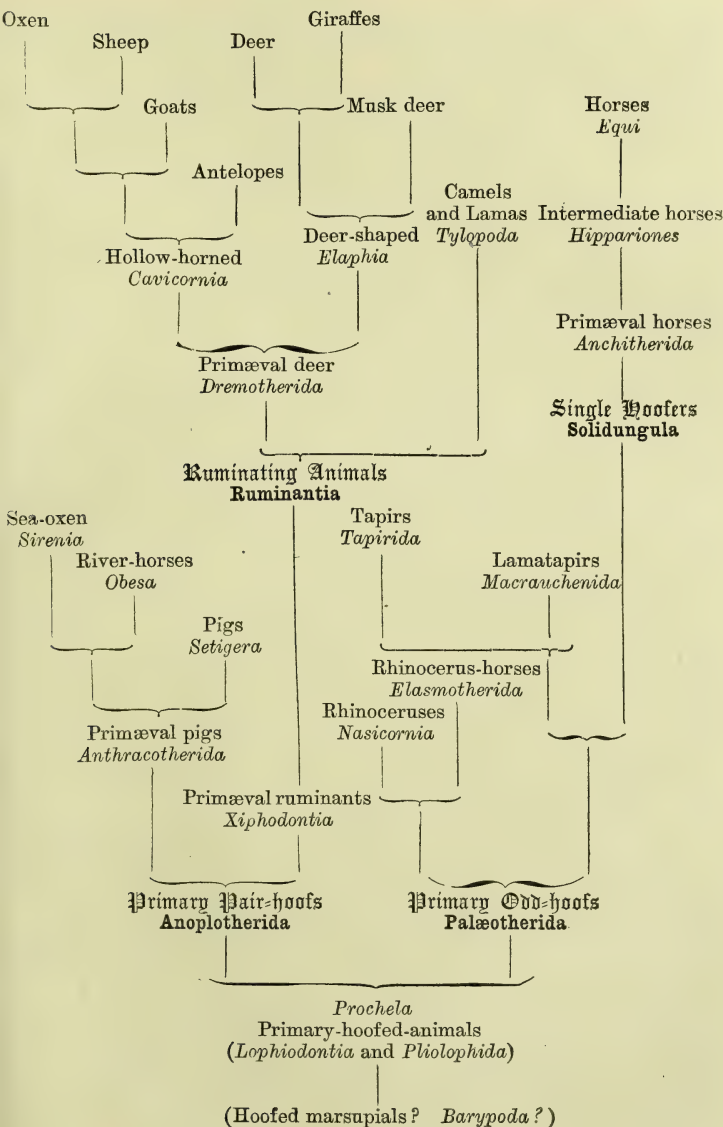
It is probable that the remarkable legion of *Whales* (Cetacea) originated out of Hoofed animals, which accustomed themselves exclusively to an aquatic life, and thereby became transformed into the shape of fish. Although these animals seem externally very like many genuine Fish, yet they are, as even Aristotle perceived, genuine Mammals. By their whole internal structure—in so far as it has not become changed by adaptation to an aquatic life—they, of all known

SYSTEMATIC SURVEY

Of the Sections and Families of Hoofed Animals, or Ungulata.

(N.B. Those families that are extinct are marked with an asterisk.)

<i>Orders of Hoofed animals.</i>	<i>Sections of Hoofed Animals.</i>	<i>Families of Hoofed Animals.</i>	<i>Systematic Name of the Families.</i>	
I. Odd-toed Hoofed Animals Ungulata Perisso- dactyla	I. Primary Hoofed Animals.* <i>Prochela</i>	{ 1. Lophiodonta 2. Pliolophida	1. Lophiodontia * 2. Pliolophida *	
		II. Tapir-shaped <i>Tapiromorpha</i>	{ 3. Primary Odd-hoofs 4. Lama-tapirs 5. Tapirs 6. Rhinoceroses 7. Rhinoceros- horses	3. Palæotherida * 4. Macrauchenida * 5. Tapirida 6. Nasicornia 7. Elasmother- rida *
	III. Single-hoofs <i>Solidungula</i>	{ 8. Primæval horses 9. Horses	8. Anchitherida * 9. Equina	
	II. Pair-toed Hoofed Animals Ungulata Artio- dactyla	IV. Pig-shaped <i>Chæromorpha</i>	{ 10. Primary Pair-hoofs 11. Primæval pigs 12. Pigs 13. River horses 14. Primæval ruminants	10. Anoplothe- rida * 11. Anthracothe- rida * 12. Setigera 13. Obesa 14. Xiphodontia *
V. Rumin- ating animals <i>Rumi- nantia</i>		A. Stag- shaped <i>Elaphia</i>	a. { 15. Primæval deer 16. Pseudo musk deer	15. Dremotherida* 16. Tragulida
		b. { 17. Musk deer 18. Deer	17. Moschida 18. Cervina	
		c. { 19. Primæval giraffes 20. Giraffes	19. Sivatherida * 20. Devexa	
	B. Hollow- horned <i>Caricornia</i>	d. { 21. Primæval gazelles 22. Gazelles	21. Antilocaprina * 22. Antilopina	
	e. { 23. Goats 24. Sheep 25. Oxen	23. Caprina 24. Ovina 25. Bovina		
c. Pad-footed <i>Tylopoda</i>	{ 26. Lamas 27. Camels	26. Auchenida 27. Camelida		



Mammals, are most closely allied to Hoofed animals, and more especially agree with them in the absence of the decidua and in the tufted placenta. Even at the present day the river-horse (*Hippopotamus*) constitutes a kind of transition form to the Sea Cows (*Sirenia*), and from this it seems most probable that the extinct primary forms of the *Cetacea* are most closely allied to the Sea Cows of the present day, and that they developed out of Pair-hoofed animals, which were related to the hippopotamus. Out of the order of *Herbivorous whales* (*Phycoceta*)—to which the sea cows belong, and which accordingly, very probably, contain the primary forms of the legion—the other order of *Carnivorous whales* (*Sarcoceta*) appears to have developed at a later period. But Huxley thinks that these latter were of quite a different origin, and that they arose out of the *Carnaria* through the Seals. Among the *Sarcoceta*, the extinct gigantic *Zeuglodonta* (*Zeugloceta*)—whose fossil skeletons some time ago excited great interest, it being thought that they were “sea serpents”—are probably only a peculiarly developed lateral branch of genuine whales (*Autoceta*), which comprise, besides the colossal whalebone whales, the cachalot or spermaceti whales, dolphins, narwhals, porpoises, etc.

The third legion of the *Indeciduata*, or *Sparsi-placentalia*, comprises the strange group of the animals *poor in teeth* (*Edentata*); it is composed of the two orders of burrowers and sloths. The order of *Burrowers* (*Effodientia*) consists of the two sub-orders of *ant eaters* (*Vermilinguia*), to which the scaled animals also belong, and the *girdle animals* (*Cingulata*), which were formerly represented by the gigantic *Glyptodons*. The order of *Sloths* (*Tardigrada*) consists of the two sub-orders of the small, still living

dwarf sloths (Bradypoda), and of the extinct unwieldy *giant sloths* (Gravigrada). The enormous fossil remains of these colossal herbivora suggest that the whole legion is becoming extinct, and that the Edentata of the present day are but a poor remnant of the mighty order of the diluvial period. The close relations between the still living South American Edentata and the extinct gigantic forms which are found beside the latter on the same part of the globe, made such an impression upon Darwin on his first visit to South America, that they even then suggested to him the fundamental idea of the Theory of Descent. (See above, vol. i. p. 134). But it is precisely the genealogy of this legion which is most difficult. The Edentata are perhaps nothing but a peculiarly developed lateral branch of the Ungulata; but it may also be that their root lies in quite another direction.

We now leave the first main group of Placental animals, the Indeciduata, and turn to the second main group, namely, the Deciduata, or animals with decidua, which are distinguished from the former by possessing a deciduous membrane, or decidua, during their embryonal life. We here meet with a very remarkable small group of animals, for the most part extinct, and which probably were the old tertiary (or eocene) ancestors of man. These are the Semi-apes, or Lemurs (Prosimiæ); these curious animals are probably the but little changed descendants of the primæval group of Placentalia which we have to consider as the common primary form of all Deciduata. They have hitherto been classed together in the same order with Apes which Blumenbach called Quadrumana (four-handed). However, I regard them as entirely distinct from these, not

merely because they differ from all Apes, much more than do the most different Apes from one another, but also because they comprise most interesting transitional forms leading to the other orders of Deciduata. I conclude from this that the few still living Semi-apes, which moreover differ very much among one another, are the last surviving remnants of a primary group now almost extinct, but which was at one time rich in forms, and out of which all the other Deciduata (possibly with the single exception of Beasts of Prey, and Pseudo-hoofed animals) have developed as diverging branches. The old primary group of Semi-apes has probably developed out of Handed or Ape-footed Marsupials (*Pedimana*), which are surprisingly like them in the transformation of their hinder feet into grasping hands. The primæval primary forms themselves (which probably originated in the eocene period) are of course long since extinct, as are also the greater portion of the transition-forms between them and all the other orders of Deciduata. However, individual remnants of the latter are preserved among the Semi-apes of the present day. Among these, the remarkable Finger-animal of Madagascar (*Chiromys madagascariensis*) constitutes the remnant of the group of the *Leptodactyla* and the transition to Rodents. The strange flying lemur in the South Sea and Sunda islands (*Galeopithecus*), the only remnant of the group of *Pteropleura*, forms a perfect intermediate stage between Semi-apes and Bats. The long-footed Semi-apes (*Tarsius*, *Otolicnus*) constitute the last remnant of that primary branch (*Macrotrarsi*) out of which the *Insectivora* developed. The short-footed forms (*Brachytarsi*) are the medium of connection between them and genuine Apes. The Short-footed Semi-apes comprise

the long-tailed Lemur, the short-tailed Lichanotus, and the Stenops, the latter of which seems to be very closely allied to the probable ancestors of man among the Semi-apes. The short-footed as well as the long-footed Prosimiæ live widely distributed over the islands of southern Asia and Africa, more especially in Madagascar; some live also on the continent of Africa. No Semi-ape, either living or in a fossil state, has as yet been found in America. They all lead a solitary, nocturnal kind of life, and climb about on trees. (Compare vol. i. p. 361.)

Among the six remaining orders of Deciduata, all of which are probably derived from long since extinct Semi-apes, the order of *Gnawing animals* (Rodentia), which is rich in forms, has remained at the lowest stage. Among these the *squirrel-like* animals (Sciuromorpha) stand nearest akin to the Pedimanous Marsupials. Out of this primary group the *mouse-like* animals (Myomorpha) and the *porcupine-like* animals (Hystricomorpha) developed probably as two diverging branches, the former of which are directly connected with the squirrel-like animals, by the eocene Myoxida, the latter by the eocene Psammoryctida. The fourth sub-order, the *hare-like* animals (Lagomorpha), probably developed only at a later period out of one of the other three sub-orders.

Very closely allied to the Rodentia is the remarkable order of *Pseudo-hoofed animals* (Chelophora). Of these there now live but two genera, indigenous to Asia and Africa, namely, Elephants (*Elephas*), and Rock Conies (*Hyrax*). Both have hitherto generally been classed among real Hoofed animals, or Ungulata, with which they agree in the formation of the feet. But an identical transformation of nails or claws into hoofs occurs also in genuine Rodentia

and in certain hoofed Rodentia (Subungulata) which live exclusively in South America. Beside smaller forms (for example, guinea pigs and gold hares) the Subungulata also include the largest of all Rodentia, namely, the Capybara Rats, which are about four feet in length. The Rock Conies, which are externally very nearly akin to Rodents, especially to the hoofed Rodents, were formerly classed among Rodentia by some celebrated zoologists, as an especial subclass (Lamnungia). Elephants, on the other hand, when not classed among Hoofed animals, were generally considered as the representatives of a special order which were called Trunked animals (Proboscidea). But the formation of the placentas of Elephants and of Hyrax agree in a remarkable manner, and are entirely distinct from those of Hoofed animals. These latter never possess a decidua, whereas Elephants and Hyrax are genuine Deciduata. Their placenta is indeed not of the form of a disc, but of a girdle, as in the case of Animals of Prey; it is very possible that the girdle-shaped placenta is but a secondary development of the discoplacenta. Thus, then, it might be thought that the Pseudo-hoofed animals have developed out of a branch of the Rodentia, and in a similar manner perhaps the Carnivora out of a branch of the Insectivora. At all events, Elephants and Hyrax in many respects, especially in the formation of important skeletal parts, of the limbs, etc., are more closely allied to the Rodentia, and more especially to hoofed Rodentia, than to genuine Hoofed animals. Moreover several extinct forms, especially the remarkable South American Arrow-toothed animals (Toxodontia), stand in many respects mid-way between Elephants and Rodentia. That the still living Elephants and Hyrax

are but the last survivors of a group of Pseudo-hoofed animals, which was once rich in forms, is proved not only by the very numerous fossil species of Elephants and Mastodon (some of which are even larger, others also much smaller than the Elephants of the present day), but also by the remarkable miocene *Dinotheria* (*Gonyognatha*), between which and their next kindred, the Elephants, there must be a long series of unknown connecting intermediate forms. Taking all things into consideration, the most probable hypothesis which can be established at present as to the origin and the relationship of Elephants, *Dinotheria*, *Toxodon*, and Hyrax is, that they are the last survivors of a group of Pseudo-hoofed animals rich in forms, which developed out of the Rodentia, and probably out of relatives of the Subungulata.

The order of *Insect Eaters* (*Insectivora*) is a very ancient group, and is next akin to the common extinct primary form of the Deciduata, as well as to the Semi-apes of the present day. It has probably developed out of Semi-apes which were closely allied to the Long-footed Lemurs (*Macro-tarsi*) of the present day. It is separated into two orders, *Menotyphla* and *Lipotyphla*; the *Menotyphla* are probably the older of the two, and are distinguished from the *Lipotyphla* by possessing an intestinal cœcum, or typhlon. The *Menotyphla* include the climbing *Tupajas* of the Sunda Isles, and the leaping *Macroscelides* of Africa. The *Lipotyphla* are represented in our country by shrew mice, moles, and hedgehogs. The *Insectivora*, in the formation of their jaws and their mode of life, are nearly akin to *Carnivora*, but are, on the other hand, by their discoplacentas and by their large seminal vesicles, allied to *Rodents*.

It is probable that the order of *Rapacious animals* (Carnaria) developed out of a long since extinct branch of Insectivora, at the beginning of the Eocene period. It is a natural group, very rich in forms, but still of very uniform organization. The Rapacious animals are sometimes also called Girdle-placentals (Zonoplacentals), although the Pseudo-hoofed animals (Chelophora), in the same way, also deserve this designation. But as the latter, in other respects, are more closely allied to the Rodentia than to Carnaria, we have already discussed them in connection with the former. Animals of prey are divided into two, externally very different, but internally very closely related, sub-orders, namely, Land animals of prey and Marine animals of prey. The *Land animals of prey* (Carnivora) comprise bears, dogs, cats, etc., whose pedigree can be approximately guessed at by means of many extinct intermediate forms. The *Marine animals of prey*, or *Seals* (Pinnipedia), comprise sea bears, sea dogs, sea lions, and walruses. Although marine animals of prey appear externally very unlike land animals of prey, yet by their internal structure, their jaw and their peculiar girdle-shaped placenta, they are very nearly akin to them, and have evidently originated out of a branch of them, probably out of a kind of weasel (Mustelina). Even at the present day the fish otters (Lutra), and still more so the sea otters (Enhydris), present a direct form of transition to Seals, and clearly show how the bodies of land Carnivora are transformed into the shape of a Seal, by adaptation to an aquatic life, and how the steering fins of marine rapacious animals have arisen out of the legs of the former. The latter consequently stand in the same relation to the former as do the Whales to

Hoofed animals among the Indeciduata. In the same way as the river-horse at present stands midway between the extreme branches of oxen and sea oxen, the sea otter still forms a surviving intermediate stage between the widely separated branches of dogs and sea dogs. In both cases the complete transformation of the external form, consequent upon adaptation to entirely different conditions of life, has not been able to efface the solid foundation of the inherited internal peculiarities.

According to Huxley's opinion, which has already been quoted, only the Herbivorous Whales (Sirenia) are derived from Hoofed animals; on the other hand, the Carnivorous Cetacea (Sarcoceta) are derived from the marine animals of prey; the Zeuglodonts would form a transition between the two latter. But in this case it would be difficult to understand the close anatomical relations which exist between the Herbivorous and Carnivorous Cetacea. The strange peculiarities in the internal and external structure which so strikingly distinguish the two groups from all other mammals would then have to be regarded only as *analogies* (caused by the same kinds of adaptation), not as *homologies* (transmitted from a common primary form). The latter, however, strikes me as being by far the more probable, and hence I have left all the Cetacea among the Indeciduata as *one* group of kindred origin.

The remarkable order of *Flying Mammals*, or *Bats* (Chiroptera), stands near to the Carnaria as well as to the Insectivora. It has become strikingly transformed by adaptation to a flying mode of life, just as marine animals of prey have become modified by adaptation to a swimming mode of life. This order probably also originated out of

the Semi-apes, with which it is even at present closely allied, through the flying lemurs (*Galeopithecus*). Of the two orders of flying animals, the insect-eating forms, or *flying mice* (*Nycterides*), probably developed out of those eating fruits, or *flying foxes* (*Pterocynes*); for the latter are, in many ways, more closely allied to Semi-apes than are the former.

We have now still to discuss the genuine Apes (*Simiæ*) as the last order of Mammals; but as, according to the zoological system, the human race belongs to this order, and as it undoubtedly developed historically out of a branch of this order, we shall devote a special chapter to a more careful examination of its pedigree and history.

CHAPTER XXII.

ORIGIN AND PEDIGREE OF MAN.

The Application of the Theory of Descent to Man.—Its Immense Importance and Logical Necessity.—Man's Position in the Natural System of Animals, among Disco-placental Animals.—Incorrect Separation of the Bimana and Quadrumana.—Correct Separation of Semi-apes from Apes.—Man's Position in the Order of Apes.—Narrow-nosed Apes (of the Old World) and Flat-nosed Apes (of America).—Difference of the two Groups.—Origin of Man from Narrow-nosed Apes.—Human Apes, or Anthropoides.—African Human Apes (Gorilla and Chimpanzee).—Asiatic Human Apes (Orang and Gibbon).—Comparison between the different Human Apes and the different Races of Men.—Survey of the Series of the Progenitors of Man.—Invertebrate Progenitors (Prochor-data) and Vertebrate Progenitors.

OF all the individual questions answered by the Theory of Descent, of all the special inferences drawn from it, there is none of such importance as the application of this doctrine to Man himself. As I remarked at the beginning of this treatise, the inexorable necessity of the strictest logic forces us to draw the special deductive conclusion from the general inductive law of the theory, that Man has developed gradually, and step by step, out of the lower Vertebrata, and more immediately out of Ape-like Mammals. That this doctrine is an inseparable part of the Theory of Descent, and hence also of the universal Theory of Development in general, is recognized by all thoughtful adherents

of the theory, as well as by all its opponents who reason logically.

But if the doctrine be true, then the recognition of the animal origin and pedigree of the human race will necessarily affect more deeply than any other progress of the human mind the views we form of all human relations, and the aims of all human science. It must sooner or later produce a complete revolution in the conception entertained by man of the entire universe. I am firmly convinced that in future this immense advance in our knowledge will be regarded as the beginning of a new period of the development of Mankind. It can only be compared to the discovery made by Copernicus, who was the first who ventured distinctly to express the opinion, that it was not the sun which moved round the earth, but the earth round the sun. Just as the *geocentric conception* of the universe—namely, the false opinion that the earth was the centre of the universe, and that all its other portions revolved round the earth—was overthrown by the system of the universe established by Copernicus and his followers, so the *anthropocentric conception* of the universe—the vain delusion that Man is the centre of terrestrial nature, and that its whole aim is merely to serve him—is overthrown by the application (attempted long since by Lamarck) of the theory of descent to Man. As Copernicus' system of the universe was mechanically established by Newton's theory of gravitation, we see Lamarck's theory of descent attain its causal establishment by Darwin's theory of selection. This comparison, which is very interesting in many respects, I have discussed in detail elsewhere.

In order to carry out this extremely important application of the Theory of Descent to man, with the necessary impartiality and objectivity, I must above all beg the reader (at least for a short time) to lay aside all traditional and customary ideas on the "Creation of Man," and to divest himself of the deep-rooted prejudices concerning it, which are implanted in the mind in earliest youth. If he fail to do this, he cannot objectively estimate the weight of the scientific arguments which I shall bring forward in favour of the animal derivation of Man, that is, of his origin out of Ape-like Mammals. We cannot here do better than imagine ourselves with Huxley to be the inhabitants of another planet, who, taking the opportunity of a scientific journey through the universe, have arrived upon the earth and have there met with a peculiar two-legged mammal called Man, diffused over the whole earth in great numbers. In order to examine him zoologically, we should pack a number of the individuals of different ages and from different lands (as we should do with the other animals collected on the earth) into large vessels filled with spirits of wine, and on our return to our own planet we should commence the comparative anatomy of all these terrestrial animals quite objectively. As we should have no personal interest in Man, in a creature so entirely different from ourselves, we should examine and criticise him as impartially and objectively as we should the other terrestrial animals. In doing this we should, of course, in the first place refrain from all conjectures and speculations on the nature of his soul, or on the spiritual side of his nature, as it is usually called. We should occupy ourselves solely with his bodily structure, and with

that natural conception of it which is offered by the history of his individual development.

It is evident that in order correctly to determine Man's position among the other terrestrial organisms we must, in the first place, follow the guidance of the natural system. We must endeavour to determine the position which belongs to Man in the natural system of animals as accurately and distinctly as possible. We shall then, if in fact the theory of descent be correct, be able from his position in the system to determine the real primary relationship, and the degree of consanguinity connecting Man with the animals most like him. The hypothetical pedigree of the human race will then follow naturally as the final result of this anatomical and systematic inquiry.

Now if, by means of comparative anatomy and ontogeny, we seek for man's position in that Natural System of animals which formed the subject of the last two chapters, the incontrovertible fact will at once present itself to us, that man belongs to the tribe, or phylum, of the Vertebrata. Every one of the characteristics, which so strikingly distinguish all the Vertebrata from all Invertebrata, is possessed by him. It has also never been doubted that of all the Vertebrata the Mammals are most closely allied to Man, and that he possesses all the characteristic features distinguishing them from all other Vertebrata. If then we further carefully examine the three different main groups or sub-classes of Mammals—the inter-connections of which were discussed in our last chapter—there cannot be the slightest doubt that Man belongs to the Placentals, and shares with all other Placentals, the important characteristics

which distinguish them from Marsupials and from Cloacals. Finally, of the two main groups of placental Mammals, the Deciduata and the Indeciduata, the group of Deciduata doubtless includes Man. For the human embryo is developed with a genuine decidua, and is thus absolutely distinguished from all the Indeciduata. Among the Deciduata we distinguish two legions, the Zonoplacentalia, with girdle-shaped placenta (Beasts of Prey and Pseudo-hoofed animals), and the Discoplacentalia, with disc-shaped placenta (all the remaining Deciduata). Man possesses a disc-shaped placenta, like all Discoplacentalia; and thus our next question must be, What is man's position in this group?

In the last chapter we distinguished the following five orders of Discoplacentalia: (1) Semi-apes; (2) Rodents; (3) Insectivora; (4) Bats; (5) Apes. The last of these five orders, that of Apes, is, as every one knows, in every bodily feature far more closely allied to Man than the four others. Hence the only remaining question now is, whether, in the system of animals, Man is to be directly classed in the order of genuine Apes, or whether he is to be considered as the representative of a special sixth order of Discoplacentalia, allied to, but more advanced than, that of the Apes.

Linnæus in his system classed Man in the same order with genuine Apes, Semi-apes, and Bats, which he called *Primates*; that is, lords, as it were the highest dignitaries of the animal kingdom. But Blumenbach, of Göttingen, separated Man as a special order, under the name of *Bimana*, or two-handed, and contrasted him with the Apes and Semi-apes under the name of *Quadrumana*, or four-handed. This classification was also adopted by Cuvier and, conse-

quently, by most subsequent zoologists. It was not until 1863 that Huxley, in his excellent work, the "Evidence as to Man's Place in Nature,"²⁶ showed that this classification was based upon erroneous ideas, and that the so-called "four-handed" Apes and Semi-apes are "two-handed" as much as man is himself. The difference between the foot and hand does not consist in the *physiological* peculiarity that the first digit or thumb is opposable to the four other digits or fingers in the hand, and is not so in the foot, for there are wild tribes of men who can oppose the first or large toe to the other four, just as if it were a thumb. They can therefore use their "grasping foot" as well as a so-called "hinder hand," like Apes. The Chinese boatmen row with this hinder hand, the Bengal workmen weave with it. The Negro, in whom the big toe is especially strong and freely moveable, when climbing seizes hold of the branches of the trees with it, just like the "four-handed" Apes. Nay, even the newly born children of the most highly developed races of men, during the first months of their life, grasp as easily with the "hinder hand" as with the "fore hand," and hold a spoon placed in its clutch as firmly with their big toe as with the thumb! On the other hand, among the higher Apes, especially the gorilla, hand and foot are differentiated as in man. (Compare Plate IV.)

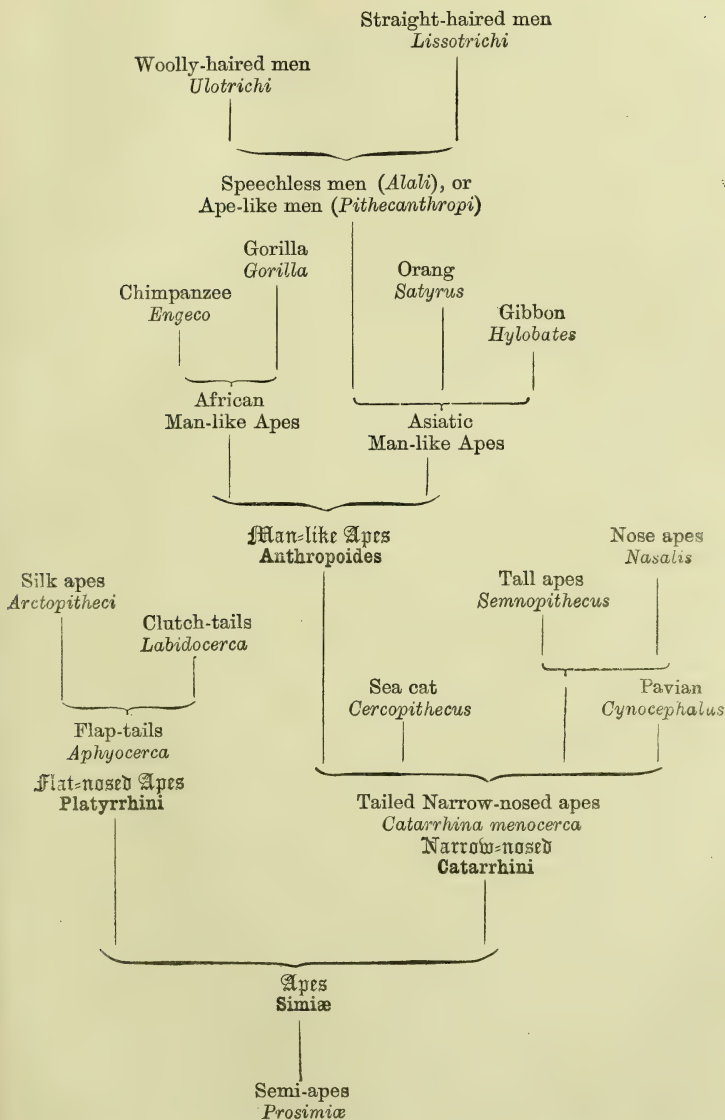
The essential difference between hand and foot is therefore not physiological, but *morphological*, and is determined by the characteristic structure of the bony skeleton and of the muscles attached to it. The ankle-bones differ from the wrist-bones in arrangement, and the foot possesses three special muscles not existing in the hand (a short

flexor muscle, a short extensor muscle, and a long fibular muscle). In all these respects, Apes and Semi-apes entirely agree with man, and hence it was quite erroneous to separate him from them as a special order on account of the stronger differentiation of his hand and foot. It is the same also with all the other structural features by means of which it was attempted to distinguish Man from Apes; for example, the relative length of the limbs, the structure of the skull, of the brain, etc. In all these respects, without exception, the differences between Man and the higher Apes are less than the corresponding differences between the higher and the lower Apes. Hence Huxley, for reasons based on the most careful and most accurate anatomical comparisons, arrives at the extremely important conclusion—"Thus, whatever system of organs be studied, the comparison of their modifications in the Ape series leads to one and the same result, that the structural differences which separate Man from the Gorilla and Chimpanzee are not so great as those which separate the Gorilla from the lower Apes." In accordance with this, Huxley, strictly following the demands of logic, classes Man, Apes, and Semi-apes in a single order, *Primates*, and divides it into the following seven families, which are of almost equal systematic value: (1) Anthropini (Man); (2) Catarrhini (genuine Apes of the Old World); (3) Platyrrhini (genuine American Apes); (4) Aреtopithecі (American clawed Apes); (5) Lemurini (short-footed and long-footed Semi-apes, p. 255); (6) Chіromyіnі (p. 256); (7) Galeopіthecіnі (Flying Lemurs, p. 256).

If we wish to arrive at a natural system, and consequently at the pedigree of the Primates, we must go a step further still, and entirely separate the Semi-apes, or Prosimiæ,

SYSTEMATIC SURVEY
Of the Families and Genera of Apes.

Sections of Apes.	Families of Apes.	Genera of Apes.	Systematic Name of the Genera.
I. APES OF THE NEW WORLD (<i>Hesperopitheci</i>), OR FLAT-NOSED APES (<i>Platyrrhini</i>).			
A. <i>Platyrrhini</i> with claws <i>Arctopitheci</i>	I. Silky apes <i>Hapalida</i>	{ 1. Brush ape 2. Lion ape	{ 1. Midas 2. Jacchus
B. <i>Platyrrhini</i> with blunt nails <i>Dysmopitheci</i>	II. Flat-nosed, without pre- hensile tail <i>Aphyocerca</i>	{ 3. Squirrel ape 4. Leaping ape 5. Nocturnal ape	{ 3. Chrysothrix 4. Callithrix 5. Nyctipithecus
	III. Flat-nosed, with prehensile tail <i>Labidocerca</i>	{ 6. Tail ape 7. Rolling ape 8. Climbing ape 9. Woolly ape 10. Howling ape	{ 6. Pithecia 7. Cebus 8. Ateles 9. Lagothrix 10. Mycetes
II. APES OF THE OLD WORLD (<i>Heopitheci</i>), OR NARROW-NOSED APES (<i>Catarrhini</i>).			
C. Tailed <i>Catarrhini</i> <i>Menocerca</i>	IV. Tailed Catar- rhini, with cheek-pouches <i>Ascoparea</i>	{ 11. Pavian 12. Macaque 13. Sea cat	{ 11. Cynocephalus 12. Inuus 13. Cercopithecus
D. Tailless <i>Catarrhini</i> <i>Lipocerca</i>	V. Tailed Catar- rhini, without cheek-pouches <i>Anasca</i>	{ 14. Holy ape 15. Short ape 16. Nose ape	{ 14. Semnopithecus 15. Colobus 16. Nasalis
	VI. Human apes <i>Anthropoides</i>	{ 17. Gibbon 18. Orang-Outan 19. Chimpanzee 20. Gorilla	{ 17. Hylobates 18. Satyrus 19. Engeco 20. Gorilla
	VII. Men <i>Erecti</i> (<i>Anthropi</i>)	{ 21. Ape-like man, or speechless man 22. Talking man	{ 21. Pithecanthropus (<i>Alalus</i>) 22. Homo



(Huxley's last three families), from Genuine Apes, or Simiæ (the first four families). For, as I have already shown in my General Morphology, and explained in the last chapter, the Semi-apes differ in many and important respects from Genuine Apes, and in their individual forms are more closely allied to the various other orders of Discoplacentalia. Hence the Semi-apes must probably be considered as the remnants of the common primary group, out of which the other orders of Discoplacentalia, and, it may be, all Deciduata, have developed as two diverging branches. (Gen. Morph. ii. pp. 148 and 153.) But man cannot be separated from the order of Genuine Apes, or Simiæ, as he is in every respect more closely allied to the higher Genuine Apes than the latter are to the lower Genuine Apes.

Genuine Apes (Simiæ) are universally divided into two perfectly natural groups, namely, the Apes of the New World, or American Apes, and the Apes of the Old World, which are indigenous to Asia and Africa, and which formerly also existed in Europe. These two classes differ principally in the formation of the nose, and they have been named accordingly. American Apes have flat noses, so that the nostrils are in front, not below; hence they are called *Flat Noses* (Platyrrhini). On the other hand, the Apes of the Old World have a narrow cartilaginous bridge, and the nostrils turned downwards, as in man; they are, therefore, called *Narrow Noses* (Catarrhini). Further, the jaw, which plays an important part in the classification of Mammals, is essentially distinct in these two groups. All Catarrhinæ, or Apes of the Old World, have exactly the same jaws as Man, namely, in each jaw four incisors above and below, then on each side a canine tooth and five cheek

teeth, of which two are pre-molars and three molars, altogether thirty-two teeth. But all Apes of the New World, all *Platyrrhini*, have four more cheek teeth, namely, three pre-molars and three molars on each side, above and below: they consequently possess thirty-six teeth. Only one small group forms an exception to this rule, namely, the *Arctopithecii*, or *Clawed Apes*, in whom the third molar has degenerated, and they accordingly have on each half of their jaw three pre-molars and two molars. They also differ from the other *Platyrrhini* by having claws on the fingers of their hands and the toes of their feet, not nails like Man and the other Apes. This small group of South American Apes, which includes among others the well-known pretty little Midas-monkey and the Jacchus, must probably be considered only as a peculiarly developed lateral branch of the *Platyrrhini*.

Now, if we ask what evidence can be drawn, as to the pedigree of Apes, from the above facts, we must conclude that all the Apes of the New World have developed out of one tribe, for they all possess the characteristic jaw and the nasal formation of the *Platyrrhini*. In like manner it follows that all the Apes of the Old World must be derived from one and the same common primary form, which possessed the same formation of nose and jaw as all the still living *Catarrhini*. Further; it can scarcely be doubted that the Apes of the New World, taken as an entire tribe, are either derived from those of the Old World, or (to express it more vaguely and cautiously) both are diverging branches of one and the same tribe of Apes. We also arrive at the exceedingly important conclusion—which is of the utmost significance in regard to Man's dis-

tribution on the earth's surface—that Man *has developed out of the Catarrhini*. For we cannot discover a zoological character distinguishing him in a higher degree from the allied Apes of the Old World than that in which the most divergent forms of this group are distinguished from one another. This is the important result of Huxley's careful anatomical examination of the question, and it cannot be too highly estimated. The anatomical differences between Man and the most human-like Catarrhini (Orang, Gorilla, Chimpanzee) are in every respect less than the anatomical differences between the latter and the lowest stages of Catarrhini, more especially the Dog-like Baboon. This exceedingly important conclusion is the result of an impartial anatomical comparison of the different forms of Catarrhini.

If, therefore, we recognise the natural system of animals as the guide to our speculations, and establish upon it our pedigree, we must necessarily come to the conclusion that *the human race is a small branch of the group of Catarrhini, and has developed out of long since extinct Apes of this group in the Old World*. Some adherents of the Theory of Descent have thought that the American races of Men have developed, independently of those of the Old World, out of American Apes. I consider this hypothesis to be quite erroneous, for the complete agreement of all mankind with the Catarrhini, in regard to the characteristic formation of the nose and jaws, distinctly proves that they are of the same origin, and that they developed out of a common root after the Platyrrhini, or American Apes, had already branched off from them. The primæval inhabitants of America, as is proved by numerous ethnographical facts,

immigrated from Asia, and partly perhaps from Polynesia (or even from Europe).

There still exist great difficulties in establishing an accurate pedigree of the Human Race; this only can we further assert, that the nearest progenitors of man were tail-less Catarrhini (Lipocerca), resembling the still living Man-like Apes. These evidently developed at a late period out of tailed Catarrhini (Menocerca), the original form of Ape. Of those tail-less Catarrhini, which are now frequently called Man-like Apes, or Anthropoides, there still exist four different genera containing about a dozen different species.

The largest Man-like Ape is the famous *Gorilla* (called *Gorilla engena*, or *Pongo gorilla*), which is indigenous to the tropics of western Africa, and was first discovered by the missionary, Dr. Savage, in 1847, on the banks of the river Gaboon. Its nearest relative is the *Chimpanzee* (*Engeco troglodytes*, or *Pongo troglodytes*), also indigenous to western Africa, but considerably smaller than the *Gorilla*, which surpasses man in size and strength. The third of the three large Man-like Apes is the *Orang*, or *Orang Outang*, indigenous to Borneo and the other Sunda Islands, of which two kindred species have recently been distinguished, namely, the large *Orang* (*Satyrus orang*, or *Pithecus satyrus*) and the small *Orang* (*Satyrus morio*, or *Pithecus morio*). Lastly, there still exists in southern Asia the genus *Gibbon* (*Hylobates*), of which from four to eight different species are distinguished. They are considerably smaller than the three first-named Anthropoides, and in most characteristics differ more from Man.

The tail-less Man-like Apes—especially since we have

become more intimately acquainted with the Gorilla, and its connection with Man by the application of the Theory of Descent—have excited such universal interest, and called forth such a flood of writings, that there is no occasion for me here to enter into any detail about them. The reader will find their relations to Man fully discussed in the excellent works of Huxley,²⁶ Carl Vogt,²⁷ Büchner,⁴³ and Rolle.²⁸ I shall therefore confine myself to stating the most important general conclusion resulting from their thorough comparison with Man, namely, that each one of the four Man-like Apes stands nearer to Man in one or several respects than the rest, but that no one of them can in every respect be called absolutely the most like Man. The Orang stands nearest to Man in regard to the formation of the brain, the Chimpanzee in important characteristics in the formation of the skull, the Gorilla in the development of the feet and hands, and, lastly, the Gibbon in the formation of the thorax.

Thus, from a careful examination of the comparative anatomy of the Anthropoides, we obtain a similar result to that obtained by Weisbach, from a statistical classification and a thoughtful comparison of the very numerous and careful measurements which Scherzer and Schwarz made of the different races of Men during their voyage in the Austrian frigate *Novara* round the earth. Weisbach comprises the final result of his investigations in the following words: "*The ape-like characteristics of Man* are by no means concentrated in one or another race, but are distributed in particular parts of the body, among the different races, in such a manner that each is endowed with some heirloom of this relationship—one race more so,

another less, and even we Europeans cannot claim to be entirely free from evidences of this relationship." *

I must here also point out, what in fact is self-evident, that not one of all the still living Apes, and consequently not one of the so-called Man-like Apes, can be the progenitor of the Human Race. This opinion, in fact, has never been maintained by thoughtful adherents of the Theory of Descent, but it has been assigned to them by their thoughtless opponents. The Ape-like progenitors of the Human Race are long since extinct. We may possibly still find their fossil bones in the tertiary rocks of southern Asia or Africa. In any case they will, in the zoological system, have to be classed in the group of *tail-less Narrow-nosed Apes* (Catarrhini Lipocerci, or Anthropoides.

The genealogical hypotheses, to which we have thus far been led by the application of the Theory of Descent to Man, present themselves to every clearly and logically reasoning person as the direct results from the facts of comparative anatomy, ontogeny, and palæontology. Of course our phylogeny can indicate only in a very general way the outlines of the human pedigree. Phylogeny is the more in danger of becoming erroneous the more rigorously it is applied in detail to special animal forms known to us. However, we can, even now, with approximate certainty distinguish at least the following twenty-two stages of the ancestors of Man. Fourteen of these stages belong to the Vertebrata, and eight to the Invertebrate ancestors of Man (Prochordata.)

* Weisbach: "Novara-Reise," Anthropolog. Theil.

THE CHAIN OF THE ANIMAL ANCESTORS, OR THE SERIES OF THE PROGENITORS, OF MAN.

(Comp. Ch. XX., XXI. ; Plate XIV. and p. 22).

FIRST HALF OF THE SERIES OF THE ANCESTORS OF MAN.

INVERTEBRATE ANCESTORS OF MAN (Prochordata).

FIRST STAGE : Monera.

The most ancient ancestors of Man, as of all other organisms, were living creatures of the simplest kind imaginable, *organisms without organs*, like the still living Monera. They consisted of simple, homogeneous, structureless and formless little lumps of mucous or albuminous matter (protoplasm), like the still living *Protamoeba primitiva*. (Compare vol. i. p. 186, Fig. 1.) The *form value* of these most ancient ancestors of man was not even equal to that of a cell, but merely that of a *cytod* (compare vol. i. p. 347); for, as in the case of all Monera, the little lump of protoplasm did not as yet possess a cell-kernel. The first of these Monera *originated* in the beginning of the Laurentian period by *spontaneous generation*, or archigony, out of so-called "inorganic combinations," namely, out of simple combinations of carbon, oxygen, hydrogen, and nitrogen. The assumption of this spontaneous generation, that is, of a mechanical origin of the first organisms from inorganic matter, has been proved in our thirteenth chapter to be a necessary hypothesis. (Compare vol. i. p. 338.) A direct

proof of the earlier existence of this most ancient ancestral stage, based upon the fundamental law of biogeny, is possibly still furnished by the circumstance that, according to the assertions of many investigators, in the beginning of the development of the egg, the cell-kernel, or nucleus, disappears, and the egg-cell thus relapses to the lower stage of the cytod (Monerula, p. 124; *relapse* of the nucleated plastid into a non-nucleated condition). The assumption of this first stage is necessary for most important general reasons.

SECOND STAGE : *Amœbæ*.

The second ancestral stage of Man, as of all the higher animals and plants, is formed by a *simple cell*, that is, a little piece of protoplasm enclosing a kernel. There still exist large numbers of similar "single-celled organisms." Among them the common, simple *Amœbæ* (vol. i. p. 188, Fig. 2) cannot have been essentially different from these progenitors. The *form value* of every *Amœba* is essentially the same as that still possessed by the egg of Man, and by the egg of all other animals. (Vol. i. p. 189, Fig. 3.) The naked egg-cells of Sponges, which creep about exactly like *Amœbæ*, cannot be distinguished from them. The egg-cell of Man, which like that of most other animals is surrounded by a membrane, resembles an enclosed *Amœba*. The first single-celled animals of this kind arose out of Monera by the differentiation of the inner kernel and the external protoplasm; they lived in the earlier Primordial period. An irrefutable proof that such single-celled primæval animals really existed as the direct ancestors of Man, is furnished according to the fundamental law of biogeny (vol. i. p. 309)

by the fact that the human egg is nothing more than a simple cell. (Compare p. 124.)

THIRD STAGE : *Synamœbæ*.

In order to form an approximate conception of the organisation of those ancestors of Man which first developed out of the single-celled Primæval animals, it is necessary to trace the changes undergone by the human egg in the beginning of its individual development. It is just here that ontogeny guides us with the greatest certainty on to the track of phylogeny. We have already seen that the egg of Man (in the same way as that of all other Mammals), after fructification has taken place, falls by self-division into a mass of simple and equi-formal Amœba-like cells (vol. i. p. 190, Fig. 4 *D*.) All these divided globules are at first exactly like one another, naked cells containing a kernel, but without covering; in many animals they show movements like those of the Amœbæ. This ontogenetic stage of development which we called Morula (p. 125), on account of its mulberry shape, is *a certain proof* that in the early primordial period there existed ancestors of man which possessed the *form value* of a mass of homogeneous, loosely connected cells. They may be called a *community of Amœbæ* (*Synamœbæ*). (Compare p. 127.) They *originated* out of the single-celled Primæval animals of the second stage by repeated self-division and by the permanent union of the products of this division.

FOURTH STAGE : Ciliated Larva (*Planœada*).

In the course of the ontogenesis of most of the lower animals, and also in that of the lowest Vertebrate animals,

the Lanceolate Animals, or Amphioxus, there first develops out of the Morula (Frontispiece, Fig. 3) a ciliated larva (planula). Those cells, lying on the surface of the homogeneous mass of cells, extend hair-like processes, or fringes of hairs, which by striking against the water keep the whole body rotating. The round many-celled body thus becomes differentiated, in that the external cells covered with cilia differ from the non-ciliated internal cells. (Frontispiece, Fig. 4). In Man and in all other Vertebrate animals (with the exception of the Amphioxus), as well as in all Arthropoda, this stage of the ciliated larva has been lost, in the course of time, by abbreviated inheritance. There must, however, have existed ancestors of Man in the early Primordial period which possessed the form value of these ciliated larvæ (Planæa, p. 125). A certain proof of this is furnished by the Amphioxus, which is on the one hand related by blood to Man, but on the other has retained down to the present day the stage of the planula.

FIFTH STAGE: Primæval Stomach Animals (Gastræada).

In the course of the individual development of Amphioxus, as well as in the most different lower animals, there first arises out of the planula the extremely important form of larva which we have named *stomach larva*, or *gastrula* (p. 126; Frontispiece, Fig. 5, 6). According to the fundamental law of biogeny this gastrula proves the former existence of an independent form of primæval animal of the same structure, and this we have named primæval stomach animal, or Gastræa (pp. 127, 128). These Gastræada must have existed during the older Primordial period, and they must have also included the ancestors of

man. A *certain proof* of this is furnished by the Amphioxus, which in spite of its blood relationship to Man still passes through the stage of the gastrula with a simple intestine and a double intestinal wall. (Compare Plate X. Fig. B 4.)

SIXTH STAGE : Gliding Worms (Turbellaria).

The human ancestors of the sixth stage which originated out of the Gastræada of the fifth stage, were low worms, which, of all the forms of worms known to us, were most closely allied to the Gliding Worms, or Turbellaria, or at least upon the whole possessed their form value. Like the Turbellaria of the present day, the whole surface of their body was covered with cilia, and they possessed a simple body of an oval shape, entirely without appendages. These acelomatous worms did not as yet possess a true body-cavity (coelom) nor blood. They *originated* in the early primordial period out of the Gastræada, by the formation of a middle germ-layer, or muscular layer, and also by the further differentiation of the internal parts into various organs; more especially the first formation of a nervous system, the simplest organs of sense, the simplest organs for secretion (kidneys) and generation (sexual organs). The proof that human ancestors existed of a similar formation, is to be looked for in the circumstance that comparative anatomy and ontogeny point to the lower acelomatous Worms as the common primary form, not merely of all higher Worms, but also of the four higher tribes of animals. Now, of all the animals known to us, the Turbellaria, which possess neither a body-cavity nor blood, are most closely allied to these primæval acelomatous Primary Worms.

SEVENTH STAGE : **Soft Worms (Scolecida).**

Between the Turbellaria of the preceding stage and the Sack Worms of the next stage, we must necessarily assume at least one connecting intermediate stage. For the Tunicata, which of all known animals stand nearest to the eighth stage, and the Turbellaria which most resemble the sixth stage, indeed both belong to the lower division of the unsegmented Worms ; but still these two divisions differ so much from one another in their organization, that we must necessarily assume the earlier existence of extinct intermediate forms between the two. These connecting links, of which no fossil remains exist, owing to the soft nature of their bodies, we may comprise as *Soft Worms*, or *Scolecida*. They developed out of the Turbellaria of the sixth stage by forming a true body-cavity (a cœlom) and blood in their interior. It is difficult to say which of the still living Cœlomati are nearest akin to these extinct Scolecida, it may be the Acorn-worms (*Balanoglossus*). The proof that even the direct ancestors of man belonged to these Scolecida, is furnished by the comparative anatomy and the ontogeny of Worms and of the *Amphioxus*. The form value of this stage must moreover have been represented by several very different intermediate stages, in the wide gap between Turbellaria and Tunicata.

EIGHTH STAGE : **Sack Worms (Himatega).**

Under the name of Sack worms, or *Himatega*, we here allude in the eighth place to those Cœlomati, out of which the most ancient skull-less Vertebrata were directly developed. Among the Cœlomati of the present day, the *Ascidians*

are the nearest relatives of these exceedingly remarkable Worms, which connect the widely differing classes of Invertebrate and Vertebrate animals. That the ancestors of man really existed during the primordial period in the form of these Himatega, is *distinctly proved* by the exceedingly remarkable and important agreement presented by the ontogeny of the Amphioxus and the Ascidia. (Compare Plates XII. and XIII., also pp. 152, 200, etc.) From this fact the earlier existence of Sack Worms may be inferred; they of all known worms were most closely related to our recent Tunicates, especially to the freely swimming young forms or larvæ of the simple Sea-squirts (Ascidia, Phallusia). They originated out of the worms of the seventh stage by the formation of a dorsal nerve-marrow (medulla tube), and by the formation of the spinal rod (chorda dorsalis) which lies below it. It is just the position of this central spinal rod, or axial skeleton, between the dorsal marrow on the dorsal side, and the intestinal canal on the ventral side, which is most characteristic of all Vertebrate animals, including man, but also of the larvæ of the Ascidia. The form value of this stage nearly corresponds with that which the larvæ of the simple Sea-squirts possess at the time when they show the beginning of the dorsal marrow and spinal rod. (Plate XII. Fig. A 5: compare the explanation of these figures in the Appendix.)

SECOND HALF OF THE SERIES OF HUMAN ANCESTORS.

VERTEBRATE ANIMAL ANCESTORS OF MAN

(Vertebrata).

NINTH STAGE : Skull-less Animals (Acrania).

The series of human ancestors, which in accordance with their whole organisation we have to consider as Vertebrate animals, begins with the Skull-less animals, or Acrania, of whose nature the still living Lancelet (*Amphioxus lanceolatus*, Plate XII. *B*, XIII. *B*) gives us a faint idea. Since this little animal in its earliest embryonal state entirely agrees with the *Ascidia*, and in its further development shows itself to be a true Vertebrate animal, it forms a direct transition from the Vertebrata to the Invertebrata. Even if the human ancestors of the ninth stage in many respects differed from the *Amphioxus*—the last surviving representative of the Skull-less animals—yet they must have resembled it in its most essential characteristics, in the absence of head, skull, and brain. Skull-less animals of such structure—out of which animals with skulls developed at a later period—lived during the primordial period, and originated out of the *Himatega* of the eighth stage by the formation of the metamera, or body segments, as also by the further differentiation of all organs, especially the more perfect development of the dorsal nerve-marrow and the spinal rod lying below it. Probably the separation of the two sexes (gonochorism) also began at this stage, whereas all the previously mentioned invertebrate ancestors (apart from the 3—4 first

neutral stages) exhibited the condition of hermaphrodites (hermaphroditism). (Compare vol. i. p. 196.) The *certain proof* of the former existence of these skull-less and brain-less ancestors of man, is furnished by the comparative anatomy and the ontogeny of the Amphioxus and of the Craniota.

TENTH STAGE : Single-nostriled Animals (Monorrhina).

Out of the Skull-less ancestors of man there arose in the first place animals with skulls, or Craniota, of the most imperfect nature. The lowest stage of all still living Craniota is occupied by the class of round-mouthed animals, or Cyclostoma, namely, the Hag (Myxinoidea) and Lampreys (Petromyzontia). From the internal organization of these single-nostriled animals, or Monorrhina, we can form an approximate idea of the nature of the human ancestors of the tenth stage. In the former, as also in the latter, skull and brain must have been of the simplest form, and many important organs, as for example, the swimming bladder, the sympathetic nerve, the spleen, the jaw skeleton, and both pairs of legs, may probably as yet not have existed. However, the pouch gills and the round sucking mouth of the Cyclostoma must probably be looked upon as purely adaptive characteristics, which did not exist in the corresponding stage of ancestors. The single-nostriled animals originated during the primordial period out of the skull-less animals by the anterior end of the dorsal marrow developing into the brain, and the anterior end of the dorsal chord into the skull. The *certain proof* that such single-nostriled and jawless ancestors of man did exist, is found in the "comparative anatomy of the Myxinoidea."

ELEVENTH STAGE : **Primæval Fish (Selachii.)**

Of all known Vertebrate animals, the ancestors of the Primæval Fish probably showed most resemblance to the still living Sharks (Squalacei). They *originated* out of the single-nostriled animals by the division of the single nostril into two lateral halves, by the formation of a sympathetic nervous system, a jaw skeleton, a swimming bladder, and two pairs of legs (breast fins or fore-legs, and ventral fins or hind-legs). The internal organisation of this stage may probably, upon the whole, have corresponded to the lowest species of Sharks known to us ; the swimming bladder was however more strongly developed ; in the case of the latter it exists only as a rudimentary organ. They *lived* as early as the Silurian period, as is proved by the fossil remains of sharks (teeth and fin spines) from the Silurian strata. A *certain proof* that the Silurian ancestors of man and of all the other double-nostriled animals were nearest akin to the Selachii, is furnished by the comparative anatomy of the latter ; it shows that the relations of organisation in all Amphirrhina can be derived from those of the Selachii.

TWELFTH STAGE : **Mud Fish (Dipneusta).**

Our twelfth ancestral stage is formed by Vertebrate animals which probably possessed a remote resemblance to the still living Salamander fish (Ceratodus, Protopterus, Lepidosiren, p. 212). They *originated* out of the Primæval fish (probably at the beginning of the palæolithic, or primary period) by adaptation to life on land, and by the transformation of the swimming bladder into an air-breathing lung, and of the nasal cavity (which now opened

into the cavity of the mouth) into air passages. The series of the ancestors of man which breathed air through lungs began at this stage. Their organisation may probably in many respects have agreed with that of the still living *Ceratodus* and *Protopterus*, but at the same time may have been very different. They probably lived at the beginning of the Devonian period. Their existence is *proved* by comparative anatomy, which shows the *Dipneusta* to be an intermediate stage between the *Selachii* and *Amphibia*.

THIRTEENTH STAGE: Gilled Amphibians (*Sozobranchia*).

Out of those Mud Fish, which we considered the primary forms of all the Vertebrata which breathe through lungs, there developed the class of Amphibia as the main line (pp. 205, 216). Here began the five-toed formation of the foot (the *Pentadactyla*), which was thence transmitted to the higher Vertebrata, and finally also to Man. The gilled Amphibians must be looked upon as our most ancient ancestors of the class of Amphibia; besides possessing lungs they retained throughout life regular gills, like the still living *Pröteus* and *Axolotl* (p. 218). They *originated* out of the *Dipneusta* by the transformation of the paddling fins into five-toed legs, and also by the more perfect differentiation of various organs, especially of the vertebral column. In any case they existed about the middle of the palæolithic, or primary period, possibly even before the Coal period; for fossil Amphibia are found in coal. The *proof* that similar gilled Amphibians were our direct ancestors, is given by the comparative anatomy and the ontogeny of Amphibia and Mammals.

FOURTEENTH STAGE : Tailed Amphibians (Sozura).

Our amphibious ancestors which retained their gills throughout life, were replaced at a later period by other Amphibia, which, by metamorphosis, lost the gills which they had possessed in early life, but retained the tail, as in the case of the salamanders and newts of the present day. (Compare p. 218.) They *originated* out of the gilled Amphibians by accustoming themselves in early life to breathe only through gills, and later in life only through lungs. They probably existed even in the second half of the primary, namely, during the Permian period, but possibly even during the Coal period. The *proof* of their existence lies in the fact that tailed Amphibians form a necessary intermediate link between the preceding and succeeding stages.

FIFTEENTH STAGE : Primæval Amniota (Protamnna).

The name Protamnion we have given to the primary form of the three higher classes of Vertebrate animals, out of which the Proreptilia and the Promammalia developed as two diverging branches (p. 222). It *originated* out of unknown tailed Amphibia by the complete loss of the gills, by the formation of the amnion, of the cochlea, and of the round window in the auditory organ, and of the organs of tears. It probably originated in the beginning of the mesolithic or secondary period, perhaps even towards the end of the primary, in the Permian period. The *certain proof* that it once existed lies in the comparative anatomy and the ontogeny of the Amniota; for all Reptiles, Birds, and Mammals, including Man, agree in so many important characteristics that they must, with full assur-

ance, be admitted to be the descendants of a single common primary form, namely, of the Protamnion.

SIXTEENTH STAGE : Primary Mammals (Promammalia).

We now find ourselves more at home with our ancestors. From the sixteenth up to the twenty-second stage they all belong to the large and well known class of Mammals, the confines of which we ourselves have as yet not transgressed. The common, long since extinct and unknown primary forms of all Mammalia, which we have named Promammalia, were at all events, of all still living animals, of the class most closely related to the Beaked animals, or Ornithostoma (Ornithorhynchus, Echidna, p. 233). They differed from the latter, however, by the teeth present in their jaws. The formation of the beak in the Beaked animals of the present day must be looked upon as an adaptive characteristic which developed at a later period. The Promammalia arose out of the Protamnion (probably only at the beginning of the secondary period, namely, in the Trias) by various advances in their internal organisation, as also by the transformation of the epidermal scales into hairs, and by the formation of a mammary gland which furnished milk for the nourishment of the young ones. The *certain proof* that the Promammalia—inasmuch as they are the common primary forms of all Mammals—also belong to our ancestors, lies in the comparative anatomy and the ontogeny of Mammalia and Man.

SEVENTEENTH STAGE : Pouched Animals (Marsupialia).

The three sub-classes of Mammalia—as we have already seen—stand in such a relation to one another that the

Marsupials, both as regards their anatomy and their ontogeny and phylogeny, form the direct transition from the Monotrema to Placental animals (p. 247). Consequently, human ancestors must also have existed among Marsupials. They *originated* out of the Monotrema—which include the primary Mammalia, or Promammalia—by the division of the cloaca into the rectum and the urogenital sinus, by the formation of a nipple on the mammary gland, and by the partial suppression of the clavicles. The oldest Marsupials at all events existed as early as the Jura period (perhaps even in the Trias), during the Chalk period they passed through a series of stages preparing the way for the origin of Placentalia. The certain proof of our derivation from Marsupials—nearly akin to the still living opossum and kangaroo in their essential inner structure—is furnished by the comparative anatomy and the ontogeny of Mammalia.

EIGHTEENTH STAGE : Semi-apes (Prosimiæ).

The small group of Semi-apes, as we have already seen, is one of the most important and most interesting orders of Mammalia. It contains the direct primary forms of Genuine Apes, and thus also of Man. Our Semi-ape ancestors probably possessed only a very faint external resemblance to the still living, short-footed Semi-apes (Brachytarsi), especially the Maki, Indri, and Lori (p. 256). They *originated* (probably at the beginning of the Cenolithic, or Tertiary period) out of Marsupials of Rat-like appearance by the formation of a placenta, the loss of the marsupium and the marsupial bones, and by the higher development of the commissures of the brain. The *certain proof* that Genuine Apes,

and hence also our own race, are the direct descendants of Semi-apes, is to be found in the comparative anatomy and the ontogeny of Placental animals.

NINETEENTH STAGE : Tailed Apes (*Menocerca*).

Of the two classes of Genuine Apes which developed out of the Semi-apes, it is only the narrow-nosed, or Catarrhini, which are closely related by blood to Man. Our older ancestors from this group probably resembled the still living Nose-apes and Holy-apes (*Semnopithecus*), which possess jaws and narrow noses like Man, but have a long tail, and their bodies densely covered with hair (p. 271). The Tailed Apes with narrow noses (*Catarrhini Menocerci*) *originated* out of Semi-apes by the transformation of the jaw, and by the claws on their toes becoming changed into nails; this probably took place as early as the older Tertiary period. The *certain proof* of our derivation from Tailed Catarrhini is to be found in the comparative anatomy and the ontogeny of Apes and of Man.

TWENTIETH STAGE : Man-like Apes (*Anthropoides*).

Of all still living Apes the large tail-less, narrow-nosed Apes, namely, the Orang and Gibbon in Asia, the Gorilla and Chimpanzee in Africa, are most nearly akin to Man. It is probable that these Man-like Apes, or *Anthropoides*, originated during the Mid-tertiary period, namely, in the Miocene period. They developed out of the Tailed Catarrhini of the preceding stage—with which they essentially agree—by the loss of the tail, the partial loss of the hairy

covering, and by the excessive development of that portion of the brain just above the facial portion of the skull. There do not exist direct human ancestors among the Anthropoides of the present day, but they certainly existed among the unknown extinct Human Apes of the Miocene period. The *certain proof* of their former existence is furnished by the comparative anatomy of Man-like Apes and of Man.

TWENTY-FIRST STAGE : **Ape-like Men (Pithecanthropi).**

Although the preceding ancestral stage is already so nearly akin to genuine Men that we scarcely require to assume an intermediate connecting stage, still we can look upon the speechless Primæval Men (Alali) as this intermediate link. These Ape-like men, or Pithecanthropi, very probably existed towards the end of the Tertiary period. They originated out of the Man-like Apes, or Anthropoides, by becoming completely habituated to an upright walk, and by the corresponding stronger differentiation of both pairs of legs. The fore hand of the Anthropoides became the human hand, their hinder hand became a foot for walking. Although these Ape-like Men must not merely by the external formation of their bodies, but also by their internal mental development, have been much more akin to real Men than the Man-like Apes could have been, yet they did not possess the real and chief characteristic of man, namely, the articulate human language of words, the corresponding development of a higher consciousness, and the formation of ideas. The *certain proof* that such Primæval Men without the power of speech, or Ape-like Men, must have preceded men possessing speech, is the result arrived at by

an inquiring mind from comparative philology (from the "comparative anatomy" of language), and especially from the history of the development of language in every child ("glottal ontogenesis") as well as in every nation ("glottal phylogenesis").

TWENTY-SECOND STAGE : **Men (Homines).**

Genuine Men, *developed* out of the Ape-like Men of the preceding stage by the gradual development of the animal language of sounds into a connected or articulate language of words. The development of this function, of course, went hand in hand with the development of its organs, namely, the higher differentiation of the larynx and the brain. The transition from speechless Ape-like Men to Genuine or Talking Men probably took place at the beginning of the Quaternary period, namely, in the Diluvial period, but possibly even at an earlier date, in the more recent Tertiary. As, according to the unanimous opinion of most eminent philologists, all human languages are not derived from a common primæval language, we must assume a polyphyletic origin of language, and in accordance with this a polyphyletic transition from speechless Ape-like Men to Genuine Men.

ANCESTRAL SERIES OF THE HUMAN PEDIGREE.

M|N = Boundary between the Invertebrate and Vertebrate Ancestors.

<i>Epochs of the Organic History of the Earth.</i>	<i>Geological Periods of the Organic History of the Earth.</i>	<i>Animal Ancestral Stages of Man.</i>	<i>Nearest Living Relatives of the Ancestral Stages.</i>
I. ARCHILITHIC OR PRIMORDIAL EPOCH	1. Laurentian Period	1. Monera (<i>Monera</i>)	{ <i>Protogenes</i> <i>Protamœba</i>
	2. Cambrian Period	2. Single-celled Primæval animals	{ Simple Amœbæ (<i>Automœbæ</i>)
		3. Many-celled Primæval animals	{ Communities of Amœbæ (<i>Synamœbæ</i>)
	3. Silurian Period	4. Ciliated planulæ (<i>Planœada</i>)	{ Planula larvæ
		5. Primæval Intestinal animals (<i>Gastrœada</i>)	{ Gastrula larvæ
		6. Gliding Worms (<i>Turbellaria</i>)	{ <i>Rhabdocœla</i> <i>Dendrocœla</i>
		7. Soft-worms (<i>Scolecida</i>)	{ ? Between the Sea-squirts and Gliding worms
		8. Sack worms (<i>Himatega</i>)	{ Sea-squirts (<i>Ascidia</i>)
		M.....N	
	(Compare p. 22, and Plate XIV. and its explanation)	9. Skull-less (<i>Acrania</i>)	{ Lancelets (<i>Amphioxi</i>)
		10. Single-nostriled (<i>Monorrhina</i>)	{ Lampreys (<i>Petromyzonta</i>)
II. PALÆOLITHIC OR PRIMARY EPOCH	4. Devonian Period	11. Primæval fish (<i>Selachii</i>)	{ Sharks (<i>Squalacæ</i>)
	5. Coal Period	12. Salamander fish (<i>Dipneusta</i>)	{ Mud fish (<i>Protopteri</i>)
	6. Permian Period	13. Gilled Amphibia (<i>Sozobranchia</i>)	{ (<i>Proteus</i>) Axolotl (<i>Siredon</i>)
		14. Tailed Amphibia (<i>Sozura</i>)	{ Water-newts (<i>Tritons</i>)
III. MESOLITHIC OR SECONDARY EPOCH	7. Trias Period	15. Primæval Amniota (<i>Protamnia</i>)	{ ? Between the Tailed Amphibia and Primary mammals
	8. Jura Period	16. Primary Mammals (<i>Promammalia</i>)	{ Beaked animals (<i>Monotrema</i>)
	9. Chalk Period	17. Pouched animals (<i>Marsupialia</i>)	{ Pouched rats (<i>Didelphys</i>)
IV. CENOLITHIC OR TERTIARY EPOCH	10. Eocene Period	18. Semi-apes (<i>Prosimia</i>)	{ Lori (<i>Stenops</i>) Maki (<i>Lemur</i>)
	11. Miocene Period	19. Tailed Narrow-nosed Apes	{ Nose apes Holy apes
		20. Men-like Apes or Tail-less Narrow-nosed Apes	{ Gorilla, Chimpanzee, Orang, Gibbon
	12. Pliocene Period	21. Speechless Men or Ape-like Men	{ Deaf and Dumb, Cretins or Microcephali
V. QUATERNARY EPOCH	13. Diluvial Period	{ 22. Talking Men	{ Australians and Papuans
	14. Alluvial Period		

CHAPTER XXIII.

MIGRATION AND DISTRIBUTION OF MANKIND.
HUMAN SPECIES AND HUMAN RACES.

Age of the Human Race.—Causes of its Origin.—The Origin of Human Language.—Monophyletic or Single, Polyphyletic or Multiple Origin of the Human Race.—Derivation of Man from many Pairs.—Classification of the Human Races.—System of Twelve Species of Men.—Woolly-Haired Men, or Ulotrichis.—Bushy-haired (Papuaans, Hottentots).—Fleecy-haired (Caffres, Negroes).—Straight-haired men, or Lissotrichi.—Stiff-haired (Australians, Malays, Mongols, Arctic, and American Tribes).—Curly-haired (Dravidas, Nubians, Midlanders).—Number of Population.—Primæval Home of Man (South Asia, or Lemuria).—Nature of Primæval Men.—Number of Primæval Languages (Monoglot-tists and Polyglottists).—Divergence and Migration of the Human Race.—Geographical Distribution of the Human Species.

THE rich treasure of knowledge we possess in the comparative anatomy and the history of the development of Vertebrate animals, enables us even now to establish the most important outlines of the human pedigree in the way we have done in the last chapter. One must, however, not expect to be able to survey satisfactorily in every detail the history or phylogeny of the human species which will henceforth form the basis of Anthropology, and of all other sciences. The complete development of this most important science—of which we can only lay the first foundation—must remain reserved for the more accurate and extensive

investigations of a future time. This applies also to those more special questions of human phylogeny at which it is desirable before concluding to take a cursory glance, namely, the question of the time and place of the origin of the human race, as also of the different species and races into which it has differentiated.

In the first place, the period of the earth's history, within which the slow and gradual transmutation of the most man-like apes into the most ape-like men took place, can of course not be determined by years, nor even by centuries. This much can, however, with full assurance be maintained, for reasons given in the last chapter, that Man is derived from Placental animals. Now, as fossil remains of these Placentalia are found only in the tertiary rocks, the human race can at the earliest have developed only within the Tertiary period out of perfected man-like apes. What seems most probable is that this most important process in the history of terrestrial creation occurred towards the end of the Tertiary period, that is in the Pliocene, perhaps even in the Miocene period, but possibly also not until the beginning of the Diluvial period. At all events Man, as such, lived in central Europe as early as the Diluvial period, contemporaneously with many large, long since extinct mammals, especially with the diluvial elephant, or mammoth (*Elephas primigenius*), the woolly-haired rhinoceros (*Rhinoceros tichorhinus*), the giant deer (*Cervus euryceros*), the cave bear (*Ursus spelæus*), the cave hyæna (*Hyæna spelæa*), the cave lion (*Felis spelæus*), etc. The results brought to light by recent geology and archæology as to these fossil men and their animal contemporaries of the diluvial period, are of the greatest interest. But as a closer examination of

them would occupy too much of my limited space, I must confine myself here to setting forth their great general importance, and refer for particulars to the numerous writings which have recently been published on the *Primæval History of Man*, more especially to the excellent works of Charles Lyell,³⁰ Carl Vogt,²⁷ Friedrich Rolle,²⁸ John Lubbock,⁴⁴ L. Büchner,⁴³ etc.

The numerous and interesting discoveries presented to us by these extensive investigations of late years on the *primæval history of the human race*, place the important fact (long since probable for many other reasons) beyond a doubt, that the human race, as such, has existed for more than twenty thousand years. But it is also probable that more than a hundred thousand years, perhaps many hundred thousands of years, have elapsed since its first appearance; and, in contrast to this, it must seem very absurd that our calendars still represent the "Creation of the World, according to Calvisius," to have taken place 5821 years ago.

Now, whether we reckon the period during which the human race, as such, has existed and diffused itself over the earth, as twenty thousand, a hundred thousand, or many hundred thousands of years, the lapse of time is in any case immensely small in comparison with the inconceivable length of time which was requisite for the gradual development of the long chain of human ancestors. This is evident even from the small thickness of all Diluvial deposits in comparison with the Tertiary, and of these again in comparison with the preceding deposits. (Compare p. 22.) But the infinitely long series of slowly and gradually developing animal forms from the simplest

Moneron to the Amphioxus, from this to the Primæval Fish, from the Primæval Fish to the first Mammal, and again, from the latter to Man, also require for their historical development a succession of periods probably comprising many thousands of millions of years. (Compare vol. i. p. 129.)

Those processes of development which led to the origin of the most Ape-like Men out of the most Man-like Apes must be looked for in the two adaptational changes which, above all others, are distinctive of Man, namely, *upright walk* and *articulate speech*. These two *physiological* functions necessarily originated together with two corresponding *morphological* transmutations, with which they stand in the closest correlation, namely, the *differentiation of the two pairs of limbs* and the *differentiation of the larynx*. The important perfecting of these organs and their functions must have necessarily and powerfully reacted upon the differentiation of the brain and the mental activities dependent upon it, and thus have paved the way for the endless career in which Man has since progressively developed, and in which he has far outstripped his animal ancestors. (Gen. Morph. ii. p. 430.)

The first and earliest of these three great processes in the development of the human organism probably was the *higher differentiation and the perfecting of the extremities* which was effected by the *habit of an upright walk*. By the fore feet more and more exclusively adopting and retaining the function of grasping and handling, and the hinder feet more and more exclusively the function of standing and walking, there was developed that contrast between the hand and foot which is indeed not exclusively characteristic of man, but which is much more strongly

developed in him than in the apes most like men. This differentiation of the fore and hinder extremities was, however, not merely most advantageous for their own development and perfecting, but it was followed at the same time by a whole series of very important changes in other parts of the body. The whole vertebral column, and more especially the girdle of the pelvis and shoulders, as also the muscles belonging to them, thereby experienced those changes which distinguish the human body from that of the most man-like apes. These transmutations were probably accomplished long before the origin of articulate speech; and the human race thus existed for long, with an upright walk and the characteristic human form of body connected with it, before the actual development of human language, which would have completed the second and the more important part of human development. We may therefore distinguish a special (21st) stage in the series of our human ancestors, namely, Speechless Man (Alalus), or Ape-man (Pithecanthropus), whose body was indeed formed exactly like that of Man in all essential characteristics, but who did not as yet possess articulate speech.

The origin of *articulate language*, and the *higher differentiation and perfecting of the larynx* connected with it, must be looked upon as only a later, and the most important stage in the process of the development of Man. It was, doubtless, this process which above all others helped to create the deep chasm between man and animal, and which also first caused the most important progress in the mental activity and the perfecting of the brain connected with it. There indeed exists in very many

animals a language for communicating sensations, desires, and thoughts, partly a language of gestures, partly a language of feeling or touch, partly a language of cries or sounds, but a real language of words or ideas, a so-called "articulate" language, which by abstraction changes sounds into words, and words into sentences, belongs, as far as we know, exclusively to Man.

The origin of human language must, more than anything else, have had an ennobling and transforming influence upon the mental life of Man, and consequently upon his brain. The higher differentiation and perfecting of the brain and mental life as its highest function developed in direct correlation with its expression by means of speech. Hence, the highest authorities in comparative philology justly see in the development of human speech the most important process which distinguishes Man from his animal ancestors. This has been especially set forth by August Schleicher, in his treatise "On the Importance of Speech for the Natural History of Man."³⁴ In this relation we see one of the closest connections between comparative zoology and comparative philology; and here the theory of development assigns to the latter the task of following the origin of language step by step. This task, as interesting as it is important, has of late years been successfully undertaken by many inquirers, but more especially by Wilhelm Bleek, who has been occupied for seventeen years in South Africa with the study of the languages of the lowest races of men, and hence has been enabled to solve the question. August Schleicher more especially discusses, in accordance with the theory of selection, how the various forms of speech, like all other organic forms and functions, have developed by

the process of natural selection, and have divided into many species and dialects.

I have no space here to follow the process of the formation of language, and must refer in regard to this to the above-mentioned important work of Wilhelm Bleek, "On the Origin of Language."³⁵ But we have still to mention one of the most important results of comparative philology, which is of the highest importance to the genealogy of the human species, that is, that *human language was probably of a multiple, or polyphyletic origin*. Human speech, as such, did not develop probably until the genus of Speechless or Primæval Man, or Ape Man, had separated into several kinds or species. In each of these human species, and perhaps even in the different sub-species and varieties of this species, language developed freely and independently of the others. At least Schleicher, one of the first authorities on the subject, maintains that "even the beginnings of language—in sounds as well as in regard to ideas and views which were reflected in sounds, and further, in regard to their capability of development—must have been different. For it is positively impossible to trace all languages to one and the same primæval language. An impartial investigation rather shows that there are as many primæval languages as there are races."³⁴ In like manner, Friederich Müller⁴¹ and other eminent linguists assume a free and independent origin of the families of languages and their primæval stocks. It is well known, however, that the boundaries of these tribes of languages and their ramifications are by no means always the boundaries of the different human species, or the so-called "races," distinguished by us on account of their bodily character-

istics. This, as well as the complicated relations of the mixture of races, and the various forms of hybrids, is the great difficulty lying in the way of tracing the human pedigree in its individual branches, species, races, varieties, etc.

In spite of these great and serious difficulties, we cannot here refrain from taking one more cursory glance at the ramification of the human pedigree, and at the same time considering, from the point of view of the theory of descent, the much discussed question of the monophyletic or polyphyletic origin of the human race, and its species or races. As is well known, two great parties have for a long time been at war with each other upon this question; the *monophylists* (or monogenists) maintain the unity of origin and the blood relationship of all races of men. The *polyphylists* (or polygenists), on the other hand, are of opinion that the different races of men are of independent origin. According to our previous genealogical investigations we cannot doubt that, at least in a *wide sense*, the monophyletic opinion is the right one. For even supposing that the transmutation of Man-like Apes into Men had taken place several times, yet those Apes themselves would again be allied by the one pedigree common to the whole order of Apes. The question therefore would always be merely about a nearer or remoter degree of blood relationship. In a *narrower sense*, on the other hand, the polyphylist's opinion would probably be right, inasmuch as the different primæval languages have developed quite independently of one another. Hence, if the origin of an articulate language is considered as the real and principal act of humanification, and the species of the human race are distinguished accord-

ing to the roots of their language, it might be said that the different races of men had originated, independently of one another, by different branches of primæval, speechless men directly springing from apes, and forming their own primæval language. Still they would of course be connected further up or lower down at their root, and thus all would finally be derived from a common primæval stock.

While we hold the latter of these convictions, and while we for many reasons believe that the different species of speechless primæval men were all derived from a common ape-like human form, we do not of course mean to say that *all men are descended from one pair*. This latter supposition, which our modern Indo-Germanic culture has taken from the Semitic myth of the Mosaic history of creation, is by no means tenable. The whole of the celebrated dispute, as to whether the human race is descended from a single pair or not, rests upon a completely false way of putting the question. It is just as senseless as the dispute as to whether all sporting dogs or all race-horses are descended from a single pair. We might with equal justice ask whether all Germans or all Englishmen are "descended from a single pair," etc. A "first human pair," or "a first man," has in fact never existed, any more than there ever existed a first pair or a first individual of Englishmen, Germans, race-horses, or sporting dogs. The origin of a new species, of course, always results from an existing species, by a long chain of many different individuals sharing the slow process of transformation. Supposing that we had all the different pairs of Human Apes and Ape-like Men before us—which belong to the true ancestors of the human race—it would even then be quite

impossible (without doing so most arbitrarily) to call any one of these pairs of ape-like men "the first pair." As little can we derive each of the twelve races or species of men, which we shall consider directly, from a "first pair."

The difficulties met with in classifying the different races or species of men are quite the same as those which we discover in classifying animal and vegetable species. In both cases forms apparently quite different are connected with one another by a chain of intermediate forms of transition. In both cases the dispute as to what is a kind or a species, what a race or a variety, can never be determined. Since Blumenbach's time, as is well known, it has been thought that mankind may be divided into five races or varieties, namely: (1) the Ethiopian, or black race (African negro); (2) the Malayan, or brown race (Malays, Polynesians, and Australians); (3) the Mongolian, or yellow race (the principal inhabitants of Asia and the Esquimaux of North America); (4) the Americans, or red race (the aborigines of America); and (5) the Caucasian, or white race (Europeans, north Africans, and south-western Asiatics). All of these five races of men, according to the Jewish legend of creation, are said to have been descended from "a single pair"—Adam and Eve,—and in accordance with this are said to be varieties of one kind or species. If, however, we compare them without prejudice, there can be no doubt that the differences of these five races are as great and even greater than the "specific differences" by which zoologists and botanists distinguish recognised "good" animal and vegetable species ("bonæ species"). The excellent palæontologist Quenstedt is right in maintaining that, "if Negroes and Caucasians were snails, zoologists would universally agree

that they represented two very excellent species, which could never have originated from one pair by gradual divergence."

The characteristics by which the races of men are gradually distinguished are partly taken from the formation of the hair, partly from the colour of the skin, and partly from the formation of the skull. In regard to the last character, two extremes are distinguished, namely, long heads and short heads. In *long-headed men* (Dolichocephali) whose strongest development is found in Negroes and Australians, the skull is extended, narrow, and compressed on the right and left. In *short-headed men* (Brachycephali), on the other hand, the skull is compressed in an exactly opposite manner, from the front to the back, is short and broad, which is especially striking in the case of the Mongolians. *Medium-headed men* (Mesocephali), standing between the two extremes, predominate especially among Americans. In every one of these three groups we find men with *slanting teeth* (Prognathi), whose jaws, like those of the animal snout, strongly project, and whose front teeth therefore slope in front, and men with *straight teeth* (Orthognathi), whose jaws project but little, and whose front teeth stand perpendicularly. During the last ten years a great deal of time and trouble have been devoted to the careful examination and measurement of the forms of skulls, which have, however, not been rewarded by corresponding results. For within a single species, as for example within the Mediterranean species, the form of the skull may vary so much that both extremes are met with in the same species. Much better starting-points for the classification of the human species are furnished by the nature of the

hair and speech, because they are much more strictly hereditary than the form of the skull.

Comparative philology seems especially to be becoming an authority in this matter. In the latest great work on the races of men, which Friederich Müller has published in his excellent "Ethnography,"⁴² he justly places language in the fore-ground. Next to it the nature of the hair of the head is of great importance; for although it is in itself of course only a subordinate morphological character, yet it seems to be strictly transmitted within the race. Of the twelve species of men distinguished on the following table (p. 308), the four lower species are characterised by the woolly nature of the hair of their heads; every hair is flattened like a tape, and thus its section is oval. These four species of *woolly-haired men* (Ulotrichi) we may reduce into two groups—tuft-haired and fleecy-haired. The hair on the head of *tuft-haired men* (Lophocomi), Papuans and Hottentots, grows in unequally divided small tufts. The woolly hair of *fleecy-haired men* (Eriocomi), on the other hand, in Caffres and Negroes, grows equally all over the skin of the head. All Ulotrichi, or woolly-haired men, have slanting teeth and long heads, and the colour of their skin, hair, and eyes is always very dark. All are inhabitants of the Southern Hemisphere; it is only in Africa that they come north of the equator. They are on the whole at a much lower stage of development, and more like apes, than most of the Lissotrichi, or straight-haired men. The Ulotrichi are incapable of a true inner culture and of a higher mental development, even under the favourable conditions of adaptation now offered to them in the United States of

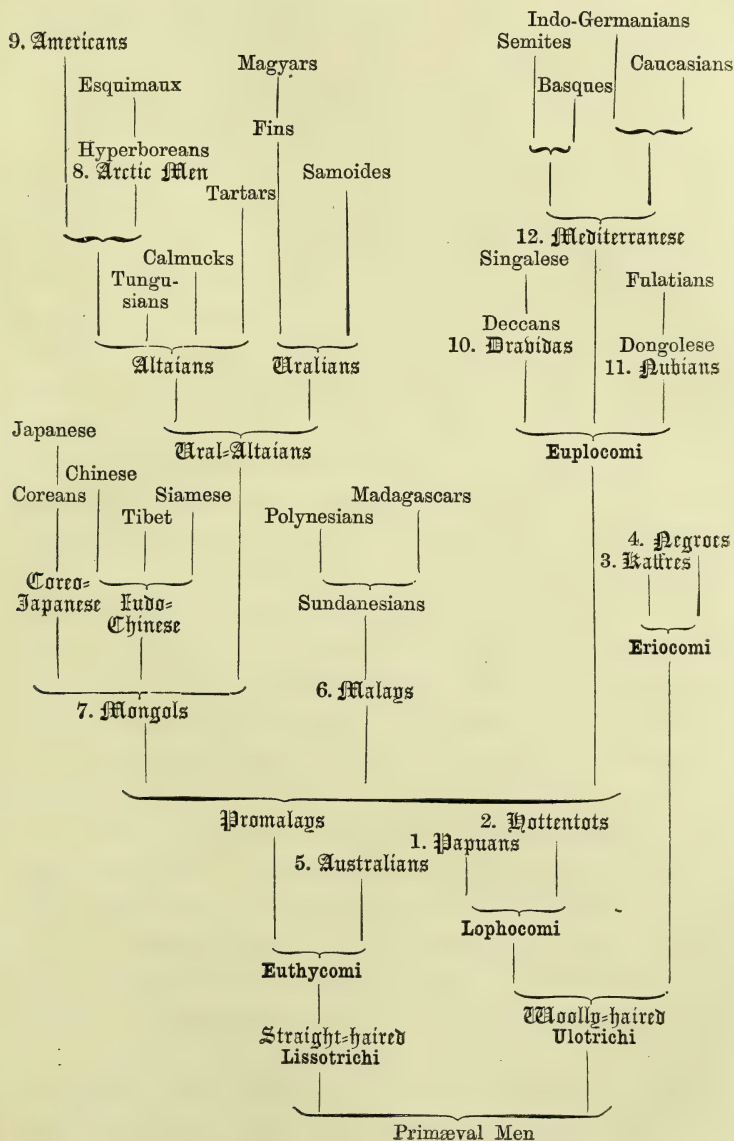
SYSTEMATIC SURVEY

Of the 12 Species of Men and their 36 Races.

(Compare Plate XV.)

<i>Species.</i>	<i>Races.</i>	<i>Home.</i>	<i>Immigrated from the</i>
{ 1. Papuan Homo Papua { 2. Hottentot Homo Hottentottus { 3. Kaffre Homo Cafer { 4. Negro Homo Niger	1. Nigritos	Malacca, Philippine Islands	West
	2. New Guinea men	New Guinea	West
	3. Melanesians	Melanesia	North-west
	4. Tasmanians	Van Diemen's Land	North-east
	5. Hottentots	The Cape	North-east
	6. Bushmen	The Cape	North-east
	7. Zulu Kaffres	Eastern South Africa	North
	8. Beschuanas	Central South Africa	North-east
	9. Congo Kaffres	Western South Africa	East
	10. Tibu negroes	Tibu district	South-east
	11. Soudan negroes	Soudan	East
	12. Senegambians	Senegambia	East
	13. Nigritians	Nigritia	East
.....			
{ 5. Australian H. Australis { 6. Malay Homo Malayus { 7. Mongolian Homo Mongolus { 8. Arctic Men Homo Arcticus { 9. American Homo Americanus { 10. Dravidas H. Dravida { 11. Nubian Homo Nuba { 12. Mediterraneæ Homo Mediterraneus	14. North Australians	North Australia	North
	15. South Australians	South Australia	North
	16. Sundanesians	Sunda Archipelago	West
	17. Polynesians	Pacific Archipelago	West
	18. Natives of Madagascar	Madagascar	East
	19. Indo-Chinese	Tibet, China	South
	20. Coreo-Japanese	Corea, Japan	South-west
	21. Altaians	Central Asia, North Asia	South
	22. Utraliens	North-western Asia, Northern Europe, Hungary	South-east
	23. Hyperboreans	Extreme N.E. of Asia	South-west
	24. Esquimos	The extreme north of America	West
	25. North Americans	North America	North-west
	26. Central Americans	Central America	North
	27. South Americans	South America	North
	28. Patagonians	The extreme south of South America	North
{ 29. Deccans H. Dravida { 30. Singalese Homo Nuba { 31. Dongolese Homo Nuba { 32. Fulatians { 33. Caucasians Homo Mediterraneus { 34. Basque Homo Mediterraneus { 35. Semites Homo Mediterraneus { 36. Indo-germanic tribes	29. Deccans	Hindustan	East ?
	30. Singalese	Ceylon	North ?
	31. Dongolese	Nubia	East
	32. Fulatians	Fulu-land (Central Africa)	East
	33. Caucasians	Caucasus	South-east
	34. Basque	Extreme north of Spain	South ?
	35. Semites	Arabia, North Africa, etc.	East
	36. Indo-germanic tribes	South-western Asia, Europe, etc.	South-east

PEDIGREE OF THE TWELVE SPECIES OF MEN. 309



North America. No woolly-haired nation has ever had an important "history."

In the eight higher races of men, which we comprise as *straight-haired* (Lissotrichi), the hair of the head is never actually woolly, although it is very much frizzled in some individuals. Every separate hair is cylindrical (not like a tape), and hence its section is circular (not oval).

The eight races of Lissotrichi may likewise be divided into two groups—stiff-haired and curly-haired. *Stiff-haired men* (Euthycomi), the hair of whose heads is quite smooth and straight, and not frizzled, include Australians, Malays, Mongolians, Arctic tribes, and Americans. Curly-haired men, on the other hand, the hair of whose heads is more or less curly, and in whom the beard is more developed than in all other species, include the Dravidas, Nubians, and Mediterranean races. (Compare Plate XV.)

Now, before we venture upon the attempt hypothetically to explain the phyletic divergence of mankind, and the genealogical connection of its different species, we will premise a short description of the twelve named species and of their distribution. In order clearly to survey their geographical distribution, we must go back some three or four centuries, to the time when the Indian Islands and America were first discovered, and when the present great mingling of species, and more especially the influx of the Indo-Germanic race, had as yet not made great progress. We begin with the lowest stages, with the woolly-haired men (Ulotrichi), all of whom are prognathic Dolichocephali.

The *Papuan* (*Homo Papua*), of all the still living human species, is perhaps most closely related to the original primary

form of woolly-haired men. This species now inhabits only the large island of New Guinea and the Archipelago of Melanesia lying to the east of it (Solomon's Islands, New Caledonia, the New Hebrides, etc.). But scattered remnants of it are also still found in the interior of the peninsula of Malacca, and likewise in many other islands of the large Pacific Archipelago; mostly in the inaccessible mountainous parts of the interior, and especially in the Philippine Islands. The but lately extinct Tasmanians, or the natives of Van Diemen's Land, belonged to this group. From these and other circumstances it is clear that the Papuans in former times possessed a much larger area of distribution in south-eastern Asia. They were driven out by the Malays and forced eastwards. The skin of all Papuans is of a black colour, sometimes more inclining to brown, sometimes more to blue. Their woolly hair grows in tufts, is spirally twisted in screws, and often more than a foot in length, so that it forms a strong woolly wig, which stands far out from the head. Their face, below the narrow depressed forehead, has a large turned-up nose and thick protruding lips. The peculiar form of their hair and speech so essentially distinguishes the Papuans from their straight-haired neighbours, from the Malays as well as from the Australians, that they must be regarded as an entirely distinct species.

Closely related to the Papuans by the tufted growth of hair, but geographically widely separated from them, are the *Hottentots* (*Homo Hottentottus*). They inhabit exclusively the southernmost part of Africa, the Cape and the adjacent parts, and have immigrated there from the north-east. The Hottentots, like their original kinsmen the Papuans, occupied in former times a much larger area (prob-

ably the whole of Eastern Africa), and are now approaching their extinction. Besides the genuine Hottentots—of whom there now exist only the two tribes of the Coraca (in the eastern Cape districts) and the Namaca (in the western portion of the Cape)—this species also includes the Bushmen (in the mountainous interior of the Cape). The woolly hair of all Hottentots grows in tufts, like brushes, as in the case of Papuans. Both species also agree in the posterior part of the body, in the female sex being specially inclined to form a great accumulation of fat (*Steatopygia*). But the skin of Hottentots is much lighter, of a yellowish brown colour. Their very flat face is remarkable for its small forehead and nose, and large nostrils. The mouth is very broad with big lips, the chin small and pointed. Their speech is characterised by several quite peculiar guttural sounds.

The next neighbours and kinsmen of Hottentots are *Kaffres* (*Homo Cafer*). This woolly-haired human species is, however, distinguished, like the following one (the genuine Negro), from Hottentots and Papuans by the woolly hair not being divided into tufts, but covering the head as a thick fleece. The colour of their skin varies through all shades, from the yellowish black of the Hottentot to the brown black or pure black of the genuine Negro. While in former times the race of Kaffres was assigned to a very small area of distribution, and was generally looked upon only as a variety of the genuine Negro, this species is now considered to include almost the whole of the inhabitants of equatorial Africa, from the 20th degree south latitude to the 4th degree north; consequently, all South Africans, with the exception of the Hottentots. They include especially the inhabitants of the Zulu, Zambesi, and Mozambique districts

on the east coast, the large human families of the Beschuan or Setschuans in the interior, and the Herrero and Congo tribes of the west coast. They too, like the Hottentots, have immigrated from the north-east. Kaffres, who were usually classed with Negroes, differ very essentially from them by the formation of their skull and by their speech. Their face is long and narrow, their forehead high, and their nose prominent and frequently curved, their lips not so protruding, and their chin pointed. The many languages of the different tribes of Kaffres can all be derived from an extinct primæval language, namely, from the Bantu language.

The genuine *Negro* (*Homo Niger*) —when Kaffres, Hottentots, and Nubians are separated from him—at present forms a much less comprehensive human species than was formerly supposed. They now only include the Tibus, in the eastern parts of the Sahara; the Sudan people, or Sudians, who inhabit the south of that large desert; also the inhabitants of the Western Coast of Africa, from the mouth of the Senegal in the north, to beyond the estuary of the Niger in the south (Senegambians and Nigritians). Genuine Negroes are accordingly confined between the equator and the Tropic of Capricorn, and only a small portion of the Tibu tribe in the east have gone beyond this boundary. The Negro species has spread within this zone, coming from the east. The colour of the skin of genuine negroes is always more or less of a pure black. Their skin is velvety to the touch, and characterised by a peculiar offensive exhalation. Although Negroes agree with Kaffres in the formation of the woolly hair of the head, yet they differ essentially in the formation of their face.

Their forehead is flatter and lower, their nose broad and thick, not prominent, their lips large and protruding, and their chin very short. Genuine Negroes are moreover distinguished by very thin calves and very long arms. This species of men must have branched into many separate tribes at a very early period, for their numerous and entirely distinct languages can in no way be traced to one primæval language.

To the four woolly-haired species of men just discussed, straight-haired men (*Homines Lissotrichi*) stand in strong contrast, as another main branch of the genus. Five of the eight species of the latter, as we have seen, can be comprised as stiff-haired (*Euthycomi*) and three as curly-haired (*Euplocomi*). We shall in the first place consider the former, which includes the primæval inhabitants of the greater part of Asia and the whole of America.

The lowest stage of all straight-haired men, and on the whole perhaps of all the still living human species, is occupied by the *Australian*, or *Austral-negro* (*Homo Australis*). This species seems to be exclusively confined to the large island of Australia; it resembles the genuine African Negro by its black or brownish black hair, and the offensive smell of the skin, by its very slanting teeth and long-headed form of skull, the receding forehead, broad nose, protruding lips, and also by the entire absence of calves. On the other hand Australians differ from genuine Negroes as well as from their nearest neighbours the Papuans, by the much weaker and more delicate structure of their bones, and more especially by the formation of the hair of their heads, which is not woolly and frizzled, but either quite lank or only slightly curled. The very low stage of bodily and mental

development of the Australian is perhaps not altogether original, but has arisen by degeneration, that is, by adaptation to the very unfavourable conditions of existence in Australia. They probably immigrated to their present home from the north or north-west, as a very early offshoot of the Euthycomi. They are probably more closely related to the Dravidas, and hence to the Euplocomi, than the other Euthycomi. The very peculiar language of the Australians is broken up into numerous small branches, which are grouped into a northern and a southern class.

The *Malay* (*Homo Malayus*), the brown race of ethnographers, although not a large species, is important in regard to its genealogy. An extinct south Asiatic human species, very closely related to the Malays of the present day, must probably be looked upon as the common primary form of this and the following higher human species. We will call this hypothetical primary species, *Primæval Malays*, or *Promalays*. The Malays of the present day are divided into two widely dispersed races, the *Sundanesians*, who inhabit Malacca, the Sunda Islands (Sumatra, Java, Borneo, etc.) and the Philippine Islands, and the *Polynesians*, who are dispersed over the greater portion of the Pacific Archipelago. The northern boundary of their wide tract of distribution is formed on the east by the Sandwich Islands (Hawai), and on the west by the Marian Islands (Ladrones); the southern boundary on the east is formed by the Mangareva Archipelago, and on the west by New Zealand. The inhabitants of Madagascar are an especial branch of Sundanesians who have been driven to the far west. This wide pelagic distribution of the Malays is explained by their partiality for nautical life. Their primæval home is the

south-eastern portion of the Asiatic continent, from whence they spread to the east and south, and drove the Papuans before them. The Malays, in the formation of body, are nearest akin to the Mongols, but are also nearly allied to the curly-haired Mediterraneans. They are generally short-headed, more rarely medium-headed, and very rarely long-headed. Their hair is black and stiff, but frequently somewhat curled. The colour of their skin is brown, sometimes yellowish, or of a cinnamon colour, sometimes reddish or copper brown, more rarely dark brown. In regard to the formation of face, Malays in a great measure form an intermediate stage between the Mongols and the Mediterraneans; they can frequently not be distinguished from the latter. Their face is generally broad, with prominent nose and thick lips, the opening for their eyes not so narrowly cut and slanting as in Mongols. The near relationship between all Malays and Polynesians is proved by their language, which indeed broke up at an early period into many small branches, but still can always be traced to a common and quite peculiar primæval language.

The *Mongol* (*Homo Mongolus*) is, next to the Mediterranean, the richest in individuals. Among them are all the inhabitants of the Asiatic Continent, excepting the Hyperboreans in the north, the few Malays in the south-east (Malacca), the Dravidas in Western India, and the Mediterranean in the south-west. In Europe this species of men is represented by the Fins and Lapps in the north, by the Osmanlis in Turkey, and the Magyars in Hungary. The colour of the Mongol is always distinguished by a yellow tone, sometimes a light pea green, or even white, sometimes a darker brownish yellow. Their hair is always

stiff and black. The form of their skull is, in the great majority of cases, decidedly short (especially in Kalmucks, Baschkirs, etc.) but frequently of medium length (Tartars, Chinese, etc.) But among them we never meet with genuine long-headed men. The narrow openings of their eyes, which are generally slanting, their prominent cheek bones, broad noses, and thick lips are very striking, as well as the round form of their faces. The language of the Mongols is probably traceable to a common primæval language; but the monosyllabic languages of the Indo-Chinese races, and the polysyllabic languages of the other Mongol races, stand in contrast as two main branches which separated at an early time. The monosyllabic tribes of the Indo-Chinese include the Tibetans, Birmans, Siamese, and Chinese. The other polysyllabic Mongols are divided into three races, namely: (1) the Coreo-Japanese (Coreans and Japanese); (2) the Altaians (Tartars, Kirgises, Kalmucks, Buriats, Tungusians); and (3) the Uralians (Samoiedes, Fins). The Magyars of Hungary are descended from the Fins.

The *Polar men* (*Homo Arcticus*) must be looked upon as a branch of the Mongolian human species. We comprise under this name the inhabitants of the Arctic Polar lands of both hemispheres, the Esquimaux (and Greenlanders) in North America, and the Hyperboreans in north-eastern Asia (Jukagirs, Tschuksches, Kuriaks, and Kamtschads.) By adaptation to the Polar climate, this human race has become so peculiarly transformed that it may be considered as a distinct species. Their stature is low and of a square build; the formation of their skull of medium size or even long; their eyes narrow and slanting like the Mongols; their cheek-bones prominent, and their mouth wide. Their

hair is stiff and black; the colour of their skin is of a light or dark brown tinge, sometimes more inclined to white or to yellow, like that of the Mongols, sometimes more to red, like that of the Americans. The languages of Polar men are as yet little known, but they differ both from the Mongolian and from the American. Polar men must probably be regarded as a remnant and a peculiarly adapted branch of that tribe of Mongols which emigrated from north-eastern Asia to North America, and populated that part of the earth.

At the time of the discovery of America, that part of the earth was peopled (setting aside the Esquimaux) only by a single human species, namely, by the *Redskins*, or *Americans* (*Homo Americanus*). Of all other human species they are most closely related to the two preceding. The form of their skull is generally a medium one, rarely short or long-headed. Their forehead broad and very low; their nose large, prominent, and frequently aquiline; their cheek-bones prominent; their lips rather thin than thick. The colour of their skin is characterised by a red fundamental tint, which is, however, sometimes pure copper-red, or light red, sometimes a deeper reddish brown, yellow brown or olive brown. The numerous languages of the various American races and tribes are extremely different, yet they agree in their original foundation. Probably America was first peopled from north-eastern Asia by the same tribe of Mongols from whom the Polar men (Hyperboreans and Esquimaux) have also branched. This tribe first spread in North America, and from thence migrated over the isthmus of Central America down to South America, at the extreme south of which the species

degenerated very much by adaptation to the very unfavourable conditions of existence. But it is also possible that Mongols and Polynesians immigrated from the west and mixed with the former tribe. In any case the aborigines of America came over from the Old World, and did not, as some suppose, in any way originate out of American apes. Catarrhini, or Narrow-nosed Apes, never at any period existed in America.

The three human species still to be considered—the Dravidas, Nubians, and Mediterraneans—agree in several characteristics which seem to establish a close relationship between them, and distinguish them from the preceding species. The chief of these characteristics is the strong development of the beard, which in all other species is either entirely wanting or but very scanty. The hair of their heads is generally not so lank and smooth as in the five preceding species, but in most cases more or less curly. Other characteristics also seem to favour our classing them in one main group of curly-haired men (Euplocomi).

The *Dravida man* (Homo Dravida) seems to stand very near the common primary form of the Euplocomi, and perhaps of Lissotrichi. At present this primæval species is only represented by the Deccan tribes in the southern part of Hindostan, and by the neighbouring inhabitants of the mountains on the north-east of Ceylon. But in earlier times this race seems to have occupied the whole of Hindostan, and to have spread even further. It shows, on the one hand, traits of relationship to the Australians and Malays; on the other, to the Mongols and Mediterraneans. Their skin is either of a light or dark brown colour; in some tribes, of a yellowish brown, in others, almost black

brown. The hair of their heads, as in Mediterranean, is more or less curled, neither quite smooth, like that of the Euthycomi, nor actually woolly, like that of the Ulotrichi. The strong development of the beard is also like that of the Mediterranean. The oval form of face seems partly to be akin to that of the Malays, partly to that of the Mediterranean. Their forehead is generally high, their nose prominent and narrow, their lips slightly protruding. Their language is now very much mixed with Indo-Germanic elements, but seems to have been originally derived from a very peculiar primæval language.

The *Nubian* (*Homo Nuba*) has caused ethnographers no fewer difficulties than the *Dravida* species. By this name we understand not merely the real Nubians (*Schangallas*, or *Dongolese*), but also their near kinsmen, the *Fulas*, or *Fellatas*. The real Nubians inhabit the countries of the Upper Nile (*Dongola*, *Schangalla*; *Barabra*, *Cordofan*); the *Fulas*, or *Fellatas*, on the other hand, have thence migrated far westward, and now inhabit a broad tract in the south of the western Sahara, hemmed in between the *Soudanians* in the north and the *Nigritos* in the south. The *Nubian* and *Fula* races are generally either classed with negroes or with the *Hamitic* races (thus with *Mediterranean*), but are so essentially different from both that they must be regarded as a distinct species. In former times they very probably occupied a large part of north-eastern Africa. The skin of the *Nubian* and *Fula* races is of a yellowish or reddish brown colour, more rarely dark brown or approaching to black. Their hair is not woolly but curled, frequently even quite smooth; its colour is dark brown or black. Their beard is much more strongly developed than in negroes.

The oval formation of their faces approaches more to the Mediterranean than to the Negro type. Their forehead is high and broad, their nose prominent and not flat, their lips not so protruding as in the negro. The language of the Nubian races seems to possess no relationship to those of genuine negroes.

The *Caucasian*, or *Mediterranean man* (*Homo Mediterraneus*), has from time immemorial been placed at the head of all races of men, as the most highly developed and perfect. It is generally called the Caucasian race, but as among all the varieties of the species, the Caucasian branch is the least important, we prefer the much more suitable appellation proposed by Friedrich Müller, namely, that of Mediterranean, or Midland men. For the most important varieties of this species, which are moreover the most eminent actors in what is called "Universal History," first rose to a flourishing condition on the shores of the Mediterranean. The former area of the distribution of this species is expressed by the name of "Indo-Atlantic" species, whereas at present it is spread over the whole earth, and is overcoming most of the other species in the struggle for existence. In bodily as well as in mental qualities, no other human species can equal the Mediterranean. This species alone (with the exception of the Mongolian) has had an actual history; it alone has attained to that degree of civilization which seems to raise man above the rest of nature.

The characteristics which distinguish the Mediterranean from the other species of the race are well known. The chief of the external features is the light colour of the skin, which however exhibits all shades, from pure white or reddish white, through yellow or yellowish brown to dark

brown or even black-brown. The growth of the hair is generally strong, the hair of the head more or less curly, the hair of the beard stronger than in any of the other species. The form of the skull shows a great development in breadth; medium heads predominate upon the whole, but long and short heads are also widely distributed. It is only in this one species of men that the body as a whole attains that symmetry in all parts, and that equal development, which we call the type of perfect human beauty. The languages of all the races of this species can by no means be traced to a single common primæval language; we must at least assume four radically different primæval languages. In accordance with this we must also assume within this one species four different races, which are only connected at their root. Two of these races, the Basques and Caucasians, now exist only as small remnants. The Basques, which in earlier times peopled the whole of Spain and the south of France, now inhabit but a narrow tract of land on the northern coast of Spain, on the Bay of Biscay. The remnant of the Caucasian race (the Daghestans, Tschercassians, Mingrelians, and Georgians) are now confined to the districts of Mount Caucasus. The language of the Caucasians as well as that of the Basques is entirely peculiar, and can be traced neither to the Semitic nor to the Indo-Germanic primæval languages.

Even the languages of the two principal races of the Mediterranean species—the Semitic and Indo-Germanic—cannot be traced to a common origin, and consequently these two races must have separated at a very early period. Semites and Indo-Germani are descended from different ape-like men. The *Semitic* race likewise separated at a

very early period into two diverging branches, namely, into the *Egyptian* and *Arabic* branches. The *Egyptian*, or *African* branch, the *Dyssemites*—which sometimes under the name of Hamites are entirely separated from the Semites—embraces the large group of Berbers, who occupy the whole of north Africa, and in earlier times also peopled the Canary Islands, and, finally, also the group of the Ethiopians, the Bedsha, Galla, Danakil, Somali, and other tribes which occupy all the north-eastern shores of Africa as far as the equator. The *Arabic*, or *Asiatic* branch, that is, the *Eusemites*, also called Semites in a narrow sense, embrace the inhabitants of the large Arabian peninsula, the primæval family of genuine Arabians (“primæval type of the Semites”), and also the most highly developed Semitic groups, the Jews, or Hebrews, and the Aramæans—the Syrians and Chaldæans. A colony of the southern Arabs (the Himjarites), which crossed the Straits of Bab-el-Mandeb, has peopled Abyssinia.

Lastly, the Indo-Germanic race, which has far surpassed all the other races of men in mental development, separated at a very early period, like the Semitic, into two diverging branches, the *Ario-Romaic* and the *Slavo-Germanic* branches. Out of the former arose on the one hand the *Arians* (Indians and Iranians), on the other the *Græco-Roman* (Greeks and Albanians, Italians and Kelts). Out of the Slavo-Germanic branch were developed on the one hand the *Slavonians* (Russian, Bulgarian, Tchech, and Baltic tribes), on the other the *Germani* (Scandinavians and Germans, Netherlands and Anglo-Saxons). August Schleicher has explained, in a very clear genealogical form, how the further ramifications of the Indo-Germanic race may

be accurately traced in detail on the basis of comparative philology.⁶ (Compare p. 331.)

The total number of human individuals at present amounts to between 1,300 and 1,400 millions. In our Tabular Survey (p. 333) 1,350 millions has been assumed as the mean number. According to an approximate estimate, as far as such a thing is possible, 1,200 millions of these are straight-haired men, only about 150 millions woolly-haired. The most highly developed species, Mongols and Mediterraneans, far surpass all the other human species in numbers of individuals, for each of them alone comprises about 550 millions. (Compare Friederich Müller's *Ethnography*, p. 30.) Of course the relative number of the twelve species fluctuates every year, and that too, according to the law developed by Darwin, that in the struggle for life the more highly developed, the more favoured and larger groups of forms, possess the positive inclination and the certain tendency to spread more and more at the expense of the lower, more backward, and smaller groups. Thus the Mediterranean species, and within it the Indo-Germanic, have by means of the higher development of their brain surpassed all the other races and species in the struggle for life, and have already spread the net of their dominion over the whole globe. It is only the Mongolian species which can at all successfully, at least in certain respects, compete with the Mediterranean. Within the tropical regions, Negroes, Kaffres, and Nubians, as also the Malays and Dravidas, are in some measure protected against the encroachments of the Indo-Germanic tribes by their being better adapted for a hot climate; the case of the arctic tribes of the polar regions is similar. But the other races,

which as it is are very much diminished in number, will sooner or later completely succumb in the struggle for existence to the superiority of the Mediterranean races. The American and Australian tribes are even now fast approaching their complete extinction, and the same may be said of the Papuans and Hottentots.

In now turning to the equally interesting and difficult question of the relative *connection, migration, and primæval home* of the twelve species of men, I must premise the remark that, in the present state of our anthropological knowledge, any answer to this question must be regarded only as a provisional hypothesis. This is much the same as with any genealogical hypothesis which we may form of the origin of kindred animal and vegetable species, on the basis of the "Natural System." But the necessary uncertainty of these special hypotheses of descent, in no way shakes the absolute certainty of the general theory of descent. Man, we may feel certain, is descended from Catarrhini, or narrow-nosed apes, whether we agree with the polyphylites, and suppose each human species, in its primæval home, to have originated out of a special kind of ape; or whether, agreeing with the monophylites, we suppose that all the human species arose only by differentiation from a single species of primæval man (*Homo primigenius*).

For many and weighty reasons we hold the monophyletic hypothesis to be the more correct, and we therefore assume a *single primæval home* for mankind, where he developed out of a long since extinct anthropoid species of ape. Of the five now existing continents, neither Australia, nor America, nor Europe can have been this primæval home, or the so-called "Paradise," the "cradle of the human race."

Most circumstances indicate southern Asia as the locality in question. Besides southern Asia, the only other of the now existing continents which might be viewed in this light is Africa. But there are a number of circumstances (especially chorological facts) which suggest that the primæval home of man was a continent now sunk below the surface of the Indian Ocean, which extended along the south of Asia, as it is at present (and probably in direct connection with it), towards the east, as far as further India and the Sunda Islands; towards the west, as far as Madagascar and the south-eastern shores of Africa. We have already mentioned that many facts in animal and vegetable geography render the former existence of such a south Indian continent very probable. (Compare vol. i. p. 361.) Scater has given this continent the name of Lemuria, from the Semi-apes which were characteristic of it. By assuming this Lemuria to have been man's primæval home, we greatly facilitate the explanation of the geographical distribution of the human species by migration. (Compare the Table of Migrations XV., and its explanation at the end.)

We as yet know of no fossil remains of the hypothetical primæval man (*Homo primigenius*) who developed out of anthropoid apes during the tertiary period, either in Lemuria or in southern Asia, or possibly in Africa. But considering the extraordinary resemblance between the lowest woolly-haired men, and the highest man-like apes, which still exist at the present day, it requires but a slight stretch of the imagination to conceive an intermediate form connecting the two, and to see in it an approximate likeness to the supposed primæval men, or ape-like men. The form of their skull was probably very long, with slanting

teeth ; their hair woolly ; the colour of their skin dark, of a brownish tint. The hair covering the whole body was probably thicker than in any of the still living human species ; their arms comparatively longer and stronger ; their legs, on the other hand, knock-kneed, shorter and thinner, with entirely undeveloped calves ; their walk but half erect.

This ape-like man very probably did not as yet possess an actual human language, that is, an articulate language of ideas. Human speech, as has already been remarked, most likely originated after the divergence of the primæval species of men into different species. The number of primæval languages is, however, considerably larger than the number of the species of men above discussed. For philologists have hitherto not been able to trace the four primæval languages of the Mediterranean species, namely, the Basque, Caucasian, Semitic, and Indo-Germanic to a single primæval language. As little can the different Negro languages be derived from a common primæval language ; hence both these species, Mediterranean and Negro, are certainly *polyglottonic*, that is, their respective languages originated after the divergence of the speechless primary species into several races had already taken place. Perhaps the Mongols, the Arctic and American tribes, are likewise polyglottonic. The Malayan species is, however, *monoglottonic* ; all the Polynesian and Sundanesian dialects and languages can be derived from a common, long since extinct primæval language, which is not related to any other language on earth. All the other human species, Nubians, Dravidas, Australians, Papuans, Hottentots, and Kaffres are likewise monoglottonic. (Compare p. 333.)

Out of speechless primæval man, whom we consider as

the common primary species of all the others, there developed in the first place—probably by natural selection—various species of men unknown to us, and now long since extinct, and who still remained at the stage of speechless ape-men (*Alalus*, or *Pithecanthropus*). Two of these species, a woolly-haired and a straight-haired, which were most strongly divergent, and consequently overpowered the others in the struggle for life, became the primary forms of the other remaining human species.

The main branch of woolly-haired men (*Ulotrichi*) at first spread only over the southern hemisphere, and then emigrated partly eastwards, partly westwards. Remnants of the eastern branch are the Papuans in New Guinea and Melanesia, who in earlier times were diffused much further west (in further India and Sundanesia), and it was not until a late period that they were driven eastwards by the Malays. The Hottentots are the but little changed remnants of the western branch; they immigrated to their present home from the north-east. It was perhaps during this migration that the two nearly related species of Caffres and Negroes branched off from them; but it may be that they owe their origin to a peculiar branch of ape-like men.

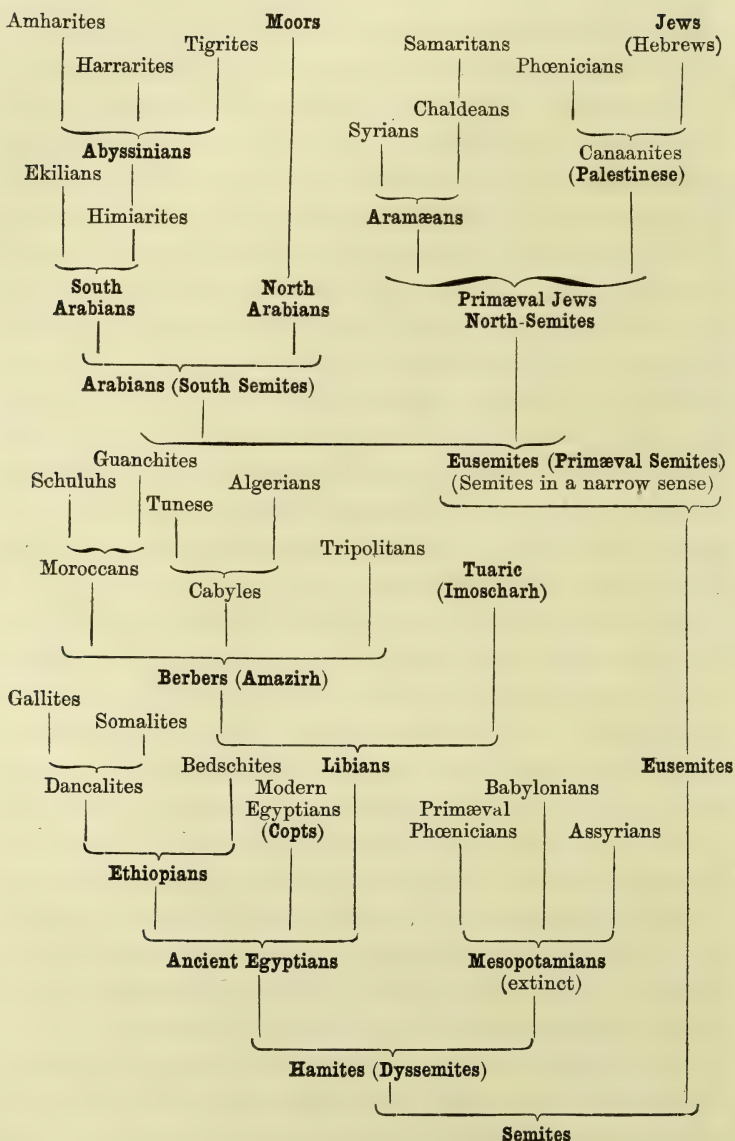
The second main branch of primæval straight-haired men (*Lissotrichi*), which is more capable of development, has probably left a but little changed remnant of its common primary form—which migrated to the south-east—in the ape-like natives of Australia. Probably very closely related to these latter are the South Asiatic *primæval Malays*, or *Promalays*, which name we have previously given to the extinct, hypothetical primary form of the other six human species. Out of this unknown common primary form there seem to have arisen three diverging branches, namely, the true

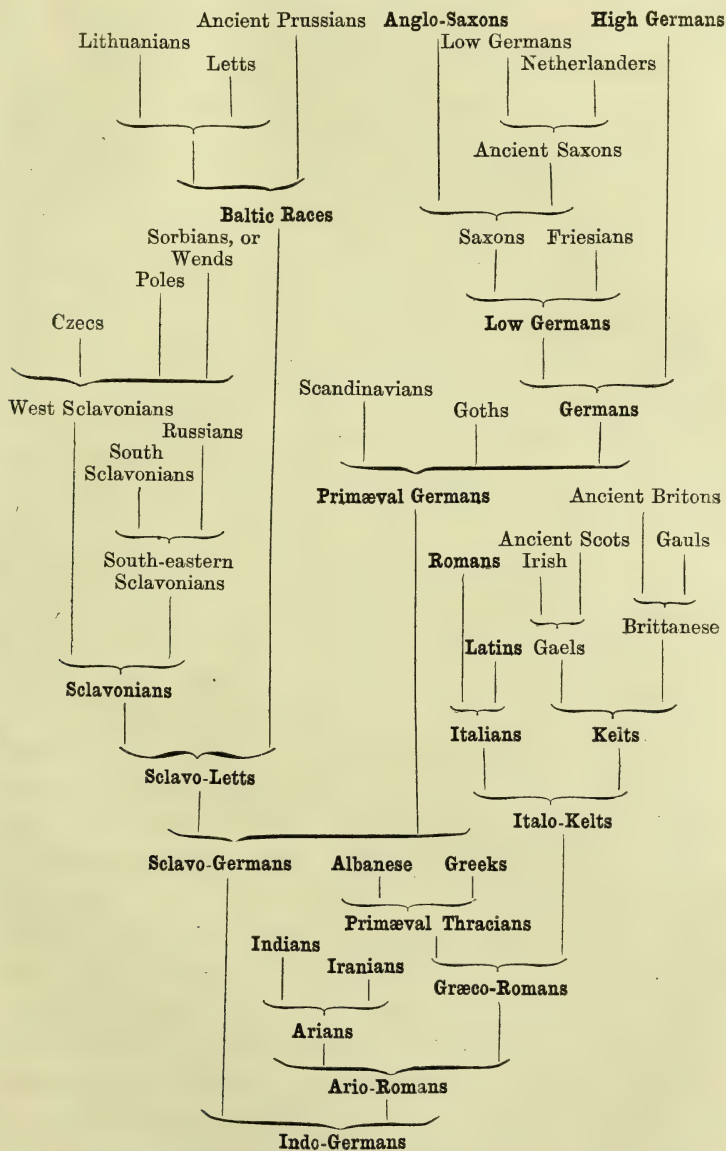
Malays, the Mongols, and the Euplocomi; the first spread to the east, the second to the north, and the third westwards.

The primæval home, or the "Centre of Creation," of the Malays must be looked for in the south-eastern part of the Asiatic continent, or possibly in the more extensive continent which existed at the time when further India was directly connected with the Sunda Archipelago and eastern Lemuria. From thence the Malays spread towards the south-east, over the Sunda Archipelago as far as Borneo, then wandered, driving the Papuans before them, eastwards towards the Samoa and Tonga Islands, and thence gradually diffused over the whole of the islands of the southern Pacific, to the Sandwich Islands in the north, the Mangareva in the east, and New Zealand in the south. A single branch of the Malayan tribe was driven far westwards and peopled Madagascar.

The second main branch of primæval Malays, that is, the Mongols, at first also spread in Southern Asia, and, radiating to the east, north, and north-west, gradually peopled the greater part of the Asiatic continent. Of the four principal races of the Mongol species, the Indo-Chinese must perhaps be looked upon as the primary group, out of which at a later period the other Coreo-Japanese and Ural-Altaian races developed as diverging branches. The Mongols migrated in many ways from western Asia into Europe, where the species is still represented in northern Russia and Scandinavia by the Fins and Lapps, in Hungary by the kindred Magyars, and in Turkey by the Osmanlis.

On the other hand, a branch of the Mongols migrated from north-eastern Asia to America, which was probably in earlier times connected with the former continent by a broad isthmus. The Arctic tribes, or Polar men, the Hyper-





boreans of north-eastern Asia, and the Esquimaux of the extreme north of America, must probably be regarded as an offshoot of this branch, which became peculiarly degenerated by unfavourable conditions of existence. The principal portion of the Mongolian immigrants, however, migrated to the south, and gradually spread over the whole of America, first over the north, later over South America.

The third and most important main branch of primæval Malays, the curly-haired races, or Euplocomi, have probably left in the Dravidas of Hindostan and Ceylon, that species of man which differs least from the common primary form of the Euplocomi. The principal portion of the latter, namely, the Mediterranean species, migrated from their primæval home (Hindostan ?) westwards, and peopled the shores of the Mediterranean, south-western Asia, north Africa, and Europe. The Nubians, in the north-east of Africa, must perhaps be regarded as an offshoot of the primæval Semitic tribes, who migrated far across central Africa almost to the western shores. The various branches of the Indo-Germanic race have deviated furthest from the common primary form of ape-like men. During classic antiquity and the middle ages, the Romanic branch (the Græco-Italo-Keltic group), one of the two main branches of the Indo-Germanic species, outstripped all other branches in the career of civilization, but at present the same position is occupied by the Germanic. Its chief representatives are the English and Germans, who are in the present age laying the foundation for a new period of higher mental development, in the recognition and completion of the theory of descent. The recognition of the theory of development and the monistic philosophy based upon it, forms the best criterion for the degree of man's mental development.

SYSTEMATIC SURVEY OF THE TWELVE HUMAN SPECIES.

N.B.—Column A denotes the Average Number of the Population in millions. Column B shows the Degree of the Phyletic Development of the Species, thus Pr = Progressive Diffusion; Co = Comparative Stability; Re = Retrogression and Extinction. Column C denotes the Character of the Primæval Language; Mn (Monoglottonic) signifies that the Species had one Simple Primæval Language; Pl (Polyglottonic, a Compound Primæval Language.

Tribe.	Human Species.	A.	B.	C.	Home.
TUFT-HAIRED Lophocomi (about 2 mil- lions)	1. PAPUAN	2	Re	Mn	{ New Guinea and Melanesia, Philippine Islands, Malacca
	2. HOTEN- TOT	$\frac{1}{20}$	Re	Mn	{ The extreme south of Africa (The Cape)
FLEECY-HAIRED Eriocomi (about 150 mil- lions)	3. KAFFRE	20	Pr	Mn	{ South Africa (between 30° S. Lat. and 5° N. Lat.)
	4. NEGRO	130	Pr	Pl	{ Central Africa (between the Equator and 30° N. Lat.)
STRAIGHT- HAISED Euthycomi (about 600 mil- lions)	5. AUSTRA- LIAN	$\frac{1}{12}$	Re	Mn	{ Australia
	6. MALAY	30	Co	Mn	{ Malacca, Sundanesia, Poly- nesia, and Madagascar
	7. MONGOL	550	Pr	Mn ?	{ The greater part of Asia and northern Europe
	8. ARCTIC MAN	$\frac{1}{23}$	Co	Pl ?	{ The extreme north-east of Asia and the extreme north of America
	9. AMERI- CAN	12	Re	Mn ?	{ The whole of America with the exception of the extreme north
	10. DRAVI- DAS	34	Co	Mn	{ South Asia (Hindostan and Ceylon)
CURLY-HAIRED Euplocomi (about 600 mil- lions)	11. NUBIAN	10	Co	Mn ?	{ Central Africa (Nubia and Fula-land)
	12. MEDI- TERRANEAN	550	Pr	Pl	{ In all parts of the world, having migrated from South Asia to North Africa and South Europe
	13. HYBRIDS OF THE SPECIES	11	Pr	Pl	{ In all parts of the world, but predominating in Ame- rica and Asia
TOTAL		1350			

CHAPTER XXIV.

OBJECTIONS AGAINST, AND PROOFS OF THE TRUTH OF,
THE THEORY OF DESCENT.

Objections to the Doctrine of Filiation.—Objections of Faith and Reason.—Immeasurable Length of the Geological Periods.—Transition Forms between Kindred Species.—Dependence of Stability of Form on Inheritance, and of the Variability of Form on Adaptation.—Origin of very complicated Arrangement of Organisation.—Gradual Development of Instincts and Mental Activities.—Origin of *à priori* Knowledge from Knowledge *à posteriori*.—The Knowledge requisite for the Correct Understanding of the Doctrine of Filiation.—Necessary Interaction between Empiricism and Philosophy.—Proofs of the Theory of Descent.—Inner Causal Connection between all the Biological Series of Phenomena.—The Direct Proof of the Theory of Selection.—Relation of the Theory of Descent to Anthropology.—Proofs of the Animal Origin of Man.—The Pithecoïd Theory as an Inseparable Part of the Theory of Descent.—Induction and Deduction.—Gradual Development of the Human Mind.—Body and Mind.—Human Soul and Animal Soul.—A Glance at the Future.

If in these chapters I may hope to have made the Theory of Descent seem more or less probable, and to have even convinced some of my readers of its unassailable truth, yet I am by no means unconscious that, to most of them, during the perusal of my explanations, a number of objections more or less well founded must have occurred. Hence it seems absolutely necessary at the conclusion of our examination to refute at least the most important of these, and

at the same time, on the other hand, once more to set forth the convincing arguments which bear testimony to the truth of the theory of development.

The objections which are raised to the doctrine of descent may be divided into two large groups: objections of faith and objections of reason. The objections of the first group originate in the infinitely varied forms of faith held by human individuals, and need not here be taken into consideration at all. For, as I have already remarked at the beginning of this book, science, as an objective result of sensuous experience, and of the striving of human reason after knowledge, has nothing whatever to do with the subjective ideas of faith, which are preached by a single man as the direct inspirations or revelations of the Creator, and then believed in by the dependent multitude. This belief, very different in different nations, only begins, as is well known, where science ends. Natural Science believes, according to the maxim of Frederick the Great, "that every one may go to heaven in his own fashion," and only necessarily enters into conflict with particular forms of faith where they appear to set a limit to free inquiry and a goal to human knowledge, beyond which we are not to venture. Now this is certainly the case here in the highest degree, for the Theory of Development applies itself to the solution of the greatest of scientific problems—that of the creation, the coming into existence of things; more especially the origin of organic forms, and of man at their head. It is here certainly the right as well as the sacred duty of free inquiry, to fear no human authority, and courageously to raise the veil from the image of the Creator, unconcerned as to what natural truth may lie con-

cealed beneath. The only Divine revelation which we recognise as true, is written everywhere in nature, and to every one with healthy senses and a healthy reason it is given to participate in the unerring revelation of this holy temple of nature, by his own inquiry and independent discovery.

If we, therefore, here disregard all objections to the Doctrine of Descent which may be raised by the priests of the different religious faiths, we must nevertheless endeavour to refute the most important of those objections which seem more or less founded on science, and which we grant might, at first sight, to a certain extent captivate us and deter us from adopting the Doctrine of Descent. Many persons seem to think the length of the periods of time required the most important of these objections. We are not accustomed to deal with such immense periods as are necessary for the history of the creation. It has already been mentioned that the periods, during which species originated by gradual transmutation, must not be calculated by single centuries, but by hundreds and by millions of centuries. Even the thickness of the stratified crust of the earth, the consideration of the immense space of time which was requisite for its deposition from water, taken together with the periods of elevation between the periods of depression, indicate a duration of time of the organic history of the earth which the human intellect cannot realize. We are here in much the same position as an astronomer in regard to infinite space. In the same way as the distances between the different planetary systems are not calculated by miles but by Sirius-distances, each of which comprises millions of miles, so the organic history of the earth must not be

calculated by thousands of years, but by palæontological or geological periods, each of which comprises many thousands of years, and perhaps millions, or even milliards, of thousands of years. It is of little importance how high the immeasurable length of these periods may be approximately estimated, because we are in fact unable with our limited power of imagination to form a true conception of these periods, and because we do not as in astronomy possess a secure mathematical basis for fixing the approximate length of duration in numbers. But we most positively deny that we see any objection to the theory of development in the extreme length of these periods which are so completely beyond the power of our imagination. It is, on the contrary, as I have already explained in one of the preceding chapters, most advisable, from a strictly philosophical point of view, to conceive these periods of creation to be as long as possible, and we are by so much the less in danger of losing ourselves in improbable hypotheses, the longer we conceive the periods for organic processes of development to have been. The longer, for example, we conceive the Permian period to have been, the easier it will be for us to understand how the important transmutations took place within it which so essentially distinguish the fauna and flora of the Coal period from that of the Trias. The great disinclination which most persons have to assume such immeasurable periods, arises mainly from the fact of our having in early youth been brought up in the notion that the whole earth is only some thousands of years old. Moreover, human life, which at most attains the length of a century, is an extremely short space of time, and is not suitable as a standard for the measure-

ment of geological periods. Our life is a single drop in the ocean of eternity. The reader may call to mind the duration of life of many trees which is more than fifty times as long; for example, the dragon-trees (*Dracæna*) and monkey bread-fruit trees (*Adansonia*), whose individual life exceeds a period of five thousand years; and, on the other hand, the shortness of the individual life of many of the lower animals, for example, the infusoria, where the individual, as such, lives but a few days, or even but a few hours, contrasts no less strongly with human longevity. This comparison brings the relative nature of all measurement of time very clearly before us. If the theory of development be true at all, there must certainly have elapsed immense periods, utterly inconceivable to us, during which the gradual historical development of the animal and vegetable kingdom proceeded by the slow transformation of species. There is, however, not a single reason for accepting a definite limit for the length of these periods of development.

A second main objection which many, and more especially systematic zoologists and botanists, raise against the theory of descent, is that no *transition forms* between the different species can be found, although according to the theory of descent they ought to be found in great numbers. This objection is partly well founded and partly not so, for there does exist an extraordinarily large number of transition forms between living, as well as between extinct species, especially where we have an opportunity of seeing and comparing very numerous individuals of kindred species. Those careful investigators of individual species who so frequently raise this objection are the very persons

whom we constantly find checked in their special series of investigations by the really insuperable difficulty of sharply distinguishing individual species. In all systematic works, which are in any degree thorough, one meets with endless complaints, that here and there species cannot be distinguished because of the excessive number of transition forms. Hence every naturalist defines the limit and the number of individual species differently. Some zoologists and botanists, as I mentioned (vol. i. p. 276), assume in one and the same group of organisms ten species, others twenty, others a hundred or more, while other systematic naturalists again look upon these different forms only as varieties of a single "good" species. In most groups of forms there is, in fact, a superabundance of transition forms and intermediate stages between the individual species.

It is true that in many species the forms of transition are actually wanting, but this is easily explained by the principle of divergence or separation, the importance of which I have already explained. The circumstance that the struggle for existence is the more active between two kindred forms the closer they stand to each other, must necessarily favour the speedy extinction of the connecting intermediate forms between the two divergent species. If one and the same species produce diverging varieties in different directions, which become new species, the struggle between these new forms and the common primary form will be the keener the less they differ from one another; but the stronger the divergence the less dangerous the struggle. Naturally therefore, it is principally the connecting intermediate forms which will in most cases

quickly die out, while the most divergent forms remain and reproduce themselves as distinct "new species." In accordance with this, we in fact no longer find forms of transition leading to those groups which are becoming extinct, as, for example, among birds, are the ostriches; and among mammals, the elephants, giraffes, Semi-apes, Edentata, and ornithorhyncus. The groups of forms approaching their extinction no longer produce new varieties, and naturally the species are what is called "good," that is, the species are distinctly different from one another. But in those animal groups where development and progress are still active, where the existing species deviate into many new species by the formation of new varieties, we find an abundance of transition forms which cause the greatest difficulties to systematic naturalists. This is the case, for example, among birds with the finches; among mammals with most of the rodents (more especially with those of the mouse and rat kind), with a number of the ruminants and with genuine apes, more especially with the South American forms (*Cebus*), and many others. The continual development of species by the formation of new varieties here produces a mass of intermediate forms which connect the so-called "good" species, which efface their boundaries, and render their sharp specific distinction completely illusory.

The reason that this nevertheless does not cause a complete confusion of forms, nor a universal chaos in the structure of animals and vegetables, lies simply in the fact that there is a continual counteraction at work between progressive *adaptation* on the one hand, and the *retentive* power of *inheritance* on the other hand. The degree of

stability and variability manifested by every organic form is determined solely by the actual condition of the equilibrium between these two opposite functions. *Inheritance is the cause of the stability of species, adaptation the cause of their modification.* When therefore some naturalists say that, according to the theory of descent, there ought to be a much greater variety of forms, and others again, that there ought to be a much greater equality of forms, the former under-estimate the value of inheritance and the latter the value of adaptation. *The ratio of the interaction between inheritance and adaptation determines the ratio of the stability and variability of organic species at any given period.*

Another objection to the theory of descent, which, in the opinion of many naturalists and philosophers is of great weight, is that it ascribes the origin of organs which act for a definite purpose to causes which are either aimless or mechanical in their operation. This objection seems to be especially important in regard to those organs which appear so excellently adapted for a certain definite purpose that the most ingenious mechanician could not invent a more perfect organ for the purpose. Such are, above all, the higher sense-organs of animals, the eye and ear. If the eyes and auditory apparatus of the higher animals alone were known to us, they would indeed cause great and perhaps insurmountable difficulties. How could we come to the conclusion that the extraordinarily great and wonderful degree of perfection and conformity to purpose which we perceive in the eyes and ears of higher animals, is in every respect attained solely by natural selection? Fortunately, however, comparative anatomy and the history of develop-

ment help us here over all obstacles; for when in the animal kingdom we follow the gradual progress towards perfection of the eyes and ears, step by step, we find such a finely graduated series of improvement, that we can clearly follow the development of the most complex organs through all the stages towards perfection. Thus, for example, the eye in the lowest animal is a simple spot of pigment which does not yet reflect any image of external objects, but at most perceives and distinguishes the different rays of light. Later, we find in addition to this a sensitive nerve; then there gradually develops within the spot of pigment the first beginning of the lens, a refractive body which is now able to concentrate the rays of light and to reflect a definite image. But all the composite apparatus for the movement of the eye and its accommodation to variations of light and distance are still absent, namely, the various refractive media, the highly differentiated membrane of the optic nerve, etc., which are so perfectly constructed in higher animals. Comparative anatomy shows us an uninterrupted succession of all possible stages of transition, from the simplest organ to the most highly perfected apparatus, so that we can form a pretty correct idea of the slow and gradual formation of even such an exceedingly complex organ. The like gradual progress which we observe in the development of the organ during the course of individual development, must have taken place in the historical (phyletic) origin of the organ.

Many persons when contemplating these most perfect organs—which apparently were purposely invented and constructed by an ingenious Creator for a definite function, but which in reality have arisen by the aimless action

of natural selection—experience difficulties in arriving at a rational understanding of them, which are similar to those experienced by the uncivilized tribes of nature when contemplating the latest complicated productions of engineering. Savages who see a ship of the line, or a locomotive engine for the first time, look upon these objects as the productions of a supernatural being, and cannot understand how a man, an organism like themselves, could have produced such an engine. Even the uneducated classes of our own race cannot comprehend such an intricate apparatus in its actual workings, nor can they understand its purely mechanical nature. Most naturalists, however, as Darwin very justly remarks, stand in much the same position in regard to the forms of organisms as do savages to ships of the line and to locomotive engines. A rational understanding of the purely mechanical origin of organic forms can only be acquired by a thorough and general training in Biology, and by a special knowledge of comparative anatomy and the history of development.

Among the remaining objections to the Theory of Descent, I shall here finally refer to and refute but one more, as in the eyes of many unscientific men it seems to possess great weight. How are we, from the Theory of Descent, to conceive of the origin of the mental faculties of animals, and more especially their specific expressions—the so-called instincts? This difficult subject has been so minutely discussed by Darwin in a special chapter of his chief work (the seventh), that I must refer the reader to it. We must regard instincts as essentially the habits of the soul acquired by adaptation, and transmitted and fixed by inheritance through many generations. Instincts are, therefore, like all other habits,

which, according to the laws of cumulative adaptation (vol. i. p. 233) and established inheritance (vol. i. p. 216), lead to the origin of new functions, and thus also to new forms of the organs. Here, as everywhere, the interaction between function and organ goes hand in hand. Just as the mental faculties of man have been acquired by the progressive adaptation of the brain, and been fixed by continual transmission by inheritance, so the instincts of animals, which differ from them only in quantity, not in quality, have arisen by the gradual perfecting of their mental organ, that is, their central nervous system, by the interaction of Adaptation and Inheritance. Instincts, as is well known, are inherited, but experiences and, consequently, new adaptations of the animal mind, are also transmitted by inheritance; and the training of domestic animals to different mental activities, which wild animals are incapable of accomplishing, rests upon the possibility of mental adaptation. We already know a series of examples, in which such adaptations, after they had been transmitted through a succession of generations, finally appeared as innate instincts, and yet they have only been acquired from the ancestors of the animals. Inheritance has here caused the result of training to become instinct. The characteristic instincts of sporting dogs, shepherd's dogs, and other domestic animals, and the natural instincts of wild animals, which they possess at birth, were in the first place acquired by their ancestors by adaptation. They may in this respect be compared to man's "knowledge *à priori*," which, like all other knowledge, was originally acquired by our remote ancestors, "*à posteriori*," by sensuous experience. As I have already remarked, it is evident that "knowledge *à priori*" arose

only by long-enduring transmission, by inheritance of acquired adaptations of the brain, out of originally empiric or experiential "knowledge à posteriori" (vol. i. p. 31).

The objections to the Theory of Descent here discussed and refuted are, I believe, the most important which have been raised against it; I consider also that I have sufficiently proved to the reader their futility. The numerous other objections which besides these have been raised against the Theory of Development in general, or against its biological part, the Theory of Descent in particular, arise either from such a degree of ignorance of empirically established facts, or from such a want of their right understanding, and from such an incapacity to draw the necessary conclusions, that it is really not worth the trouble to go further into the refutation. There are only some general points in regard to which, I should like, in a few words, to draw attention.

In the first place I must observe, that in order thoroughly to understand the doctrine of descent, and to be convinced of its absolute truth, it is indispensable to possess a general knowledge of the whole of the domain of biological phenomena. *The theory of descent is a biological theory*, and hence it may with fairness and justice be demanded that those persons who wish to pass a valid judgment upon it should possess the requisite degree of biological knowledge. Their possessing a special empiric knowledge of this or that domain of zoology or botany, is not sufficient; they must possess a *general insight into the whole series of phenomena*, at least in the case of one of the three organic kingdoms. They ought to know what universal laws result from the comparative morphology and physiology of organisms, but more especially from comparative anatomy, from the indi-

vidual and the palæontological history of development, etc.; and they ought to have some idea of the deep *mechanical, causal connection* between all these series of phenomena. It is self-evident that a certain degree of general culture, and especially a philosophical education, is requisite; which is, however, unfortunately by many persons in our day, not considered at all necessary. *Without the necessary connection of empirical knowledge and the philosophical understanding of biological phenomena, it is impossible to gain a thorough conviction of the truth of the Theory of Descent.*

Now I ask, in the face of this first preliminary condition for a true understanding of the Theory of Descent, what we are to think of the confused mass of persons who have presumed to pass a written or oral judgment upon it of an adverse character? Most of them are unscientific persons, who either know nothing of the most important phenomena of Biology, or at least possess no idea of their deeper significance. What should we say of an unscientific person who presumed to express an opinion on the cell-theory, without ever having seen cells; or of one who presumed to question the vertebral-theory, without ever having studied comparative anatomy? And yet one may meet with such ridiculous arrogance any day in the history of the biological Theory of Descent. One hears thousands of unscientific and but half-educated persons pass a final judgment upon it, although they know nothing either of botany or of zoology, of comparative anatomy or the theory of tissues, of palæontology or embryology. Hence it happens, as Huxley well says, that most of the writings published against Darwin are not worth the paper upon which they are written.

We might add that there are many naturalists, and even

celebrated zoologists and botanists, among the opponents of the Theory of Descent; but these latter are mostly old stagers, who have grown grey in quite opposite views, and whom we cannot expect, in the evening of their lives, to submit to a reform in their conception of the universe, which has become to them a fixed idea.

It is, moreover, expressly to be remarked, that not only a general insight into the *whole* domain of biological phenomena, but also a philosophical understanding of it, are the necessary preliminary conditions for becoming convinced of and adopting the Theory of Descent. Now we shall find that these indispensable preliminary conditions are, unfortunately, by no means fulfilled by the majority of naturalists of the present day. The immense amount of empirical facts with which the gigantic advances of modern natural science have recently made us acquainted has led to a prevailing inclination for the special study of single phenomena and of small and narrow domains. This causes the knowledge of other paths, and especially of Nature as a great comprehensive whole, to be in most cases completely neglected. Every one with sound eyes and a microscope, together with industry and patience for study, can in our day attain a certain degree of celebrity by microscopic "discoveries," without, however, deserving the name of a naturalist. This name is deserved only by him who not merely strives to *know* the individual phenomena, but who also seeks to *discover* their causal connection. Even in our own day, most palæontologists examine and describe fossils without knowing the most important facts of embryology. Embryologists, on the other hand, follow the history of development of a particular

organic individual, without having an idea of the palæontological history of the whole tribe, of which fossils are the records. And yet these two branches of the organic history of development—ontogeny, or the history of the individual, and phylogeny, or the history of the tribe—stand in the closest causal connection, and the one cannot be understood without the other. The same may be said of the systematic and the anatomical part of Biology. There are even now, in zoology and botany, many systematic naturalists who work with the erroneous idea that it is possible to construct a natural system of animals and plants simply by a careful examination of the external and readily accessible forms of bodies, without a deeper knowledge of their internal structure. On the other hand, there are anatomists and histologists who think it possible to obtain a true knowledge of animal and vegetable bodies merely by a most careful examination of the inner structure of the body of some individual species, without the comparative examination of the bodily form of all kindred organisms. And yet here, as everywhere, the internal and external factors, to wit, Inheritance and Adaptation, stand in the closest mutual relation, and the individual can never be thoroughly understood without a comparison of it with the whole of which it is a part. To those one-sided specialists we should like in Goethe's words to say:—

We must, contemplating Nature,
Part as Whole, give equal heed to :
Nought is inward, nought is outward,
For the inner is the outer.*

* Müsset im Naturbetrachten
Immer Eins wie Alles achten.
Nichts ist drinnen, Nichts ist draussen,
Denn was innen, das ist auszen.

And again:—

Nature has neither kernel nor shell,
It is she that is All and All at once.*

What is even more detrimental to the general understanding of nature as a whole than this one-sided tendency, is *the want of a philosophical culture*, and this applies to most of the naturalists of the present day. The various errors of the earlier speculative nature-philosophy made during the first thirty years of our century, have brought the whole of philosophy into such bad repute with the exact empirical naturalists, that they live in the strange delusion that it is possible to erect the edifice of natural science out of mere facts, without their philosophic connection; in short, out of mere knowledge, without the understanding of it. But as a purely speculative and absolutely philosophical system, which does not concern itself with the indispensable foundation of empirical facts, becomes a castle in the air, which the first real experiment throws to the winds; so, on the other hand, a purely empirical system, constructed of nothing but facts, remains a disorderly heap of stones, which will never deserve the name of an edifice. Bare facts established by experience are nothing but rude stones, and without their thoughtful valuation, without their philosophic connection, no science can be established. As I have already tried to impress upon my reader, the *strong edifice of true monistic science*, or what is the same thing, the *Science of Nature*, exists only by the closest interaction, and the reciprocal penetration of philosophy and empirical knowledge.

* Natur hat weder Kern noch Schale,
Alles ist sie mit einem Male.

This lamentable estrangement between science and philosophy, and the rude empiricism which is now-a-days unfortunately praised by most naturalists as "exact science," have given rise to those strange freaks of the understanding, to those gross insults against elementary logic, and to that incapacity for forming the simplest conclusions which one may meet with any day in all branches of science, but especially in zoology and botany. It is here that the neglect of a philosophical culture and training of the mind, directly avenges itself most painfully. It is not to be wondered at that the deep inner truth of the Theory of Descent remains a sealed book to those rude empiricists. As the common proverb justly says: they cannot see the wood for the trees. It is only by a more general philosophical study, and especially by a more strictly logical training of the mind, that this sad state of things can be remedied. (Compare Gen. Morph. i. 63; ii. 447.)

If we rightly consider this circumstance, and if we further reflect upon it in connection with the empirical foundation of the philosophical theory of development, we shall at once see how we are placed respecting the oft-demanded *proofs of the theory of descent*. The more the doctrine of filiation has of late years made way for itself, and the more all thoughtful, younger naturalists, and all truly biologically-educated philosophers have become convinced of its inner truth and absolute necessity, the louder have its opponents called for actual proofs. The same persons who, shortly after the publication of Darwin's work, declared it to be "a groundless, fantastic system," an "arbitrary speculation," an "ingenious dream," now kindly condescend to declare that the theory of descent certainly

is a scientific "*hypothesis*," but that it still requires to be "*proved*." When these remarks are made by persons who do not possess the requisite empirico-philosophical culture, nor the necessary knowledge in comparative anatomy, embryology, and palæontology, we cannot be much offended, and we refer them to the study of those sciences. But when similar remarks are made by acknowledged specialists, by teachers of zoology and botany, who certainly ought to possess a general insight into the whole domain of their science, or who are actually familiar with the facts of those scientific domains, then we are really at a loss what to say. Those who are not satisfied with the treasures of our present empirical knowledge of nature as a basis on which to establish the Theory of Descent, will not be convinced by any other facts which may hereafter be discovered; for we can conceive no circumstances which would furnish stronger or a more complete testimony to the truth of the doctrine of filiation than is even now seen, for example, in the well-known facts of comparative anatomy and ontogeny. I must here again direct attention to the fact, *that all the great and general laws, and all the comprehensive series of phenomena of the most different domains of biology can only be explained and understood by the Theory of Development* (and especially by its biological part, the Theory of Descent), and that without it they remain completely inexplicable and incomprehensible. *The internal causal connection* between them all proves the Theory of Descent to be the greatest *inductive law* of Biology.

Before concluding, I will once more name all those series of inductions, all those general laws of Biology, upon which this comprehensive law of development is firmly based.

(1.) *The palæontological history of the development of organisms*, the gradual appearance and the historical succession of the different species and groups of species, the empirical laws of the palæontological change of species, as furnished to us by the science of fossils, and more especially the *progressive differentiation and perfecting* of animal and vegetable groups in the successive periods of the earth's history.

(2.) *The individual history of development of organisms*, embryology and metamorphology, the gradual changes in the slow development of the body and its particular organs, especially *the progressive differentiation and perfecting* of the organs and parts of the body in the successive periods of the individual development.

(3.) *The inner causal connection between ontogeny and phylogeny*, the parallelism between the individual history of the development of organisms, and the palæontological history of the development of their ancestors, a connection which is actually established by the laws of *Inheritance* and *Adaptation*, and which may be summed up in the words: ontogeny, according to the laws of inheritance and adaptation, repeats in its large features the outlines of phylogeny.

(4.) *The comparative anatomy of organisms*, the proof of the essential agreement of the inner structure of kindred organisms, in spite even of the greatest difference of external form in the various species; their explanation by the causal dependence of the internal agreement of the structure on *Inheritance*, the external dissimilarity of the bodily form on *Adaptation*.

(5.) *The inner causal connection between comparative*

anatomy and the history of development, the harmonious agreement between the laws of the gradual development, *the progressive differentiation and perfecting*, as they may be seen in comparative anatomy on the one hand, in ontogeny and palæontology on the other.

(6.) *Dysteleology, or the theory of purposelessness*, the name I have given to the *science of rudimentary organs*, of suppressed and degenerated, aimless and inactive, parts of the body; one of the most important and most interesting branches of comparative anatomy, which, when rightly estimated, is alone sufficient to refute the fundamental error of the teleological and dualistic conception of Nature, and to serve as the foundation of the mechanical and monistic conception of the universe.

(7.) *The natural system of organisms*, the natural grouping of all the different forms of Animals, Plants, and Protista into numerous smaller or larger groups, arranged beside and above one another; the kindred connection of species, genera, families, orders, classes, tribes, etc., more especially, however, the *arboriform branching character of the natural system*, which is the spontaneous result of a natural arrangement and classification of all these graduated groups or categories. The result attained in attempting to exhibit the relationships of the mere forms of organisms by a tabular classification is only explicable when regarded as the expression of their actual *blood relationship*; *the tree shape of the natural system* can only be understood as the actual *pedigree of the organisms*.

(8.) *The chorology of organisms*, the science of the local distribution of organic species, of their *geographical and topographical dispersion over the surface of the earth*, over

the heights of mountains and in the depths of the ocean, but especially the important phenomenon that every species of organism proceeds from a so-called "*centre of creation*" (more correctly a "*primæval home*," or "*centre of distribution*"); that is, from a single locality, where it originated but once, and whence it spread.

(9.) *The œcology of organisms*, the knowledge of the sum of the *relations of organisms to the surrounding outer world*, to organic and inorganic conditions of existence; the so-called "*economy of nature*," the correlations between all organisms living together in one and the same locality, their adaptation to their surroundings, their modification in the struggle for existence, especially the circumstances of parasitism, etc. It is just these phenomena in "the economy of nature" which the unscientific, on a superficial consideration, are wont to regard as the wise arrangements of a Creator acting for a definite purpose, but which on a more attentive examination show themselves to be the necessary results of mechanical causes.

(10.) *The unity of Biology as a whole*, the deep inner connection existing between all the phenomena named and all the other phenomena belonging to zoology, protistics, and botany, and which are simply and naturally explained by a single common principle. This principle can be no other than the common derivation of all the specifically different organisms from a single, or from several absolutely simple, primary forms like the Monera, which possess no organs. The Theory of Descent, by assuming this common derivation, throws a clear light upon these individual series of phenomena, as well as upon their totality, without which their deeper causal connection would remain completely

incomprehensible to us. The opponents of the Theory of Descent can in no way explain any single one of these series of phenomena or their deeper connection with one another. So long as they are unable to do this, *the Theory of Descent remains the one adequate biological theory.*

We should, on account of the grand proofs just enumerated, have to adopt Lamarck's Theory of Descent for the explanation of biological phenomena, even if we did not possess Darwin's Theory of Selection. The one is so completely and *directly proved* by the other, and established by mechanical causes, that there remains nothing to be desired. The laws of *Inheritance* and *Adaptation* are universally acknowledged *physiological* facts, the former traceable to *propagation*, the latter to the *nutrition* of organisms. On the other hand, the *struggle for existence* is a *biological* fact, which with mathematical necessity follows from the general disproportion between the average number of organic individuals and the numerical excess of their germs. But as Adaptation and Inheritance in the struggle for life are in continual interaction, it inevitably follows that *natural selection*, which everywhere influences and continually changes organic species, must, by making use of *divergence of character*, produce new species. Its influence is further especially favoured by the active and passive *migrations* of organisms, which go on everywhere. If we give these circumstances due consideration, the continual and gradual modification or transmutation of organic species will appear as a biological process, which must, according to causal law, of *necessity* follow from the actual nature of organisms and their mutual correlations.

That even the *origin of man* must be explained by this general organic process of transmutation, and that it is simply as well as naturally explained by it, has, I believe, been sufficiently proved in my last chapter but one. I cannot, however, avoid here once more directing attention to the inseparable connection between this so-called "theory of apes," or "pithecoïd theory," and the whole Theory of Descent. If the latter is the greatest *inductive law* of biology, then it of necessity follows that the former is its most important *deductive law*. They stand and fall together. As all depends upon a right understanding of this proposition, which in my opinion is very important, and which I have therefore several times brought before the reader, I may be allowed to explain it here by an example.

In all mammals known to us the centre of the nervous system is the spinal marrow and the brain, and the centre of the vascular system is a quadrupal heart, consisting of two principal chambers and two ante-chambers. From this we draw the general inductive conclusion that all mammals, without exception, those extinct, together with all those living species as yet unknown to us, as well as the species which we have examined, possess a like organization, a like heart, brain, and spinal marrow. Now if, as still happens every year, there be discovered in any part of the earth a new species of mammal, a new species of marsupial, or a new species of deer, or a new species of ape, every zoologist knows with certainty at once, without having examined its inner structure, that this species must possess a quadruple heart, a brain and spinal marrow, like all other mammals. Not a single naturalist would ever think of supposing that

the central nervous system of this new species of mammal could possibly consist of a ventral cord with an œsophageal collar as in the insects, or of scattered pairs of knots as in the molluscs, or that its heart could be many-chambered as in flies, or one-chambered as in the tunicates, This completely certain and safe conclusion, although it is not based upon any direct experience, is a *deductive conclusion*. In the same way, as I have shown in a previous chapter, Goethe, from the comparative anatomy of mammals, established the general inductive conclusion that they all possess a mid jawbone, and afterwards drew from it the special deductive conclusion that man, who in all other respects does not essentially differ from other mammals, must also possess a like mid jawbone. He maintained this conclusion without having actually seen the human mid jawbone, and only proved its existence subsequently by actual observation (vol. i. p. 84).

The process of *induction* is a logical system of forming conclusions *from the special to the general*, by which we advance from many individual experiences to a general law; *deduction*, on the other hand, draws a conclusion *from the general to the special*, from a general law of nature to an individual case. Thus the *Theory of Descent* is, without doubt, a great *inductive law*, empirically based upon all the biological experience cited above; the pithecoïd theory, on the other hand, which asserts that man has developed out of lower, and in the first place out of ape-like mammals, is a *deductive law* inseparably connected with the general inductive law.

The pedigree of the human race, the approximate outlines of which I gave in the last chapter but one, of course

remains in detail (like all the pedigrees of animals and plants previously discussed) a more or less approximate general hypothesis. This however does not affect the application of the theory of descent to man. Here, as in all investigations on the derivation of organisms, one must clearly distinguish between the general *theory* of descent and the special *hypotheses* of descent. The general *theory* of descent claims full and lasting value, because it is an inductive law, based upon all the whole series of biological phenomena and their inner causal connection. Every special *hypothesis* of descent, on the other hand, has its special value determined by the existing condition of our biological knowledge, and by the extent of the objective empirical basis upon which we deductively establish this particular hypothesis. Hence, all the individual attempts to obtain a knowledge of the pedigree of any one group of organisms possesses but a temporary and conditional value, and any special hypothesis relating to it will become the more and more perfect the greater the advance we make in the comparative anatomy, ontogeny, and palæontology of the group in question. The more, however, we enter into genealogical details, and the further we trace the separate off-shoots and branches of the pedigree, the more uncertain and subjective becomes our special *hypothesis* of descent on account of the incompleteness of our empirical basis. This however does no injury to the general *theory* of descent, which remains as the indispensable foundation for really profound apprehension of biological phenomena. Accordingly, there can be no doubt that we can and must, with full assurance, regard the derivation of man—in the first place, from ape-like forms; further back, from lower

mammals, and thus continually further back to lower stages of the vertebrata down to their lowest invertebrate roots, nay, even down to a simple plastid—as a general *theory*. On the other hand, the special tracing of the human pedigree, the closer definition of the animal forms known to us, which either actually belong to the ancestors of man, or at least stand in very close blood relationship to them, will always remain a more or less approximate *hypothesis* of descent, all the more in danger of deviating from the real pedigree the nearer it endeavours to approach it by searching for the individual ancestral forms. This state of things results from the immense gaps in our palæontological knowledge, which can, under no circumstances, ever attain to even an approximate completeness.

A thoughtful consideration of this important circumstance at once furnishes the answer to a question which is commonly raised in discussing this subject, namely, the question of scientific *proofs for the animal origin of the human race*. Not only the opponents of the Theory of Descent, but even many of its adherents who are wanting in the requisite philosophical culture, look too much for “signs” and for special empirical advances in the science of nature. They await the sudden discovery of a human race with tails, or of a talking species of ape, or of other living or fossil transition forms between man and the ape, which shall fill the already narrow chasm between the two, and thus empirically “prove” the derivation of man from apes. Such special manifestations, were they ever so convincing and conclusive, would not furnish the proof desired. Unthinking persons, or those unacquainted with the series of biological phenomena, would still be able to maintain the

objections to those special testimonies which they now maintain against our theory.

The absolute certainty of the Theory of Descent, even in its application to man, is built on a more solid foundation; and its true inner value can never be tested simply by reference to individual experience, but only by a philosophical comparison and estimation of the treasures of all our biological experiences. The inestimable importance of the Theory of Descent is surely based upon this, that the theory follows of necessity (as a general inductive law) from the comparative synthesis of all organic phenomena of nature, and more especially from the triple parallelism of comparative anatomy, of ontogeny, and phylogeny; and the pithecoïd theory under all circumstances (apart from all special proofs) remains as a special deductive conclusion which must of necessity be drawn from the general inductive law of the Theory of Descent.

In my opinion, all depends upon a right understanding of this *philosophical foundation of the Theory of Descent* and of the *pithecoïd theory* which is inseparable from it. Many persons will probably admit this, and yet at the same time maintain that all this applies only to the *bodily*, not to the *mental* development of man. Now, as we have hitherto been occupied only with the former, it is perhaps necessary here to cast a glance at the latter, in order to show that it is also subject to the great general law of development. In doing this it is above all necessary to recollect that body and mind can in fact never be considered as distinct, but rather that both sides of nature are inseparably connected, and stand in the closest interaction. As even Goethe has clearly expressed it—"matter can never exist and

act without mind, and mind never without matter." The artificial discord between mind and body, between force and matter, which was maintained by the erroneous dualistic and teleological philosophy of past times has been disposed of by the advances of natural science, and especially by the theory of development, and can no longer exist in face of the prevailing mechanical and monistic philosophy of our day. How human nature, and its position in regard to the rest of the universe, is to be conceived of according to the modern view, has been minutely discussed by Radenhausen in his "Isis,"³³ which is excellent and well worth perusal.

With regard to the origin of the human mind or the soul of man, we, in the first place, perceive that in every human individual it develops from the beginning, step by step and gradually, just like the body. In a newly born child we see that it possesses neither an independent consciousness, nor in fact clear ideas. These arise only gradually when, by means of sensuous experience, the phenomena of the outer world affect the central nervous system. But still the little child is wanting in all those differentiated emotions of the soul which the full-grown man acquires only by the long experience of years. From this graduated development of the human soul in every single individual we can, in accordance with the inner causal connection between ontogeny and phylogeny, directly infer the gradual development of the human soul in all mankind, and further, in the whole of the vertebrate tribe. In its inseparable connection with the body, the human soul or mind has also had to pass through all those gradual stages of development, all those various degrees of differentiation and perfecting, of which the hypothetical series

of human ancestors sketched in a late chapter gives an approximate representation.

It is true that this conception generally greatly offends most persons on their first becoming acquainted with the Theory of Development, because more than all others it most strongly contradicts the traditional and mythological ideas, and the prejudices which have been held sacred for thousands of years. But like all other functions of organisms, the human soul must necessarily have historically developed, and the comparative or empirical study of animal psychology clearly shows that this development can only be conceived of as a gradual evolution from the soul of vertebrate animals, as a gradual differentiation and perfecting which, in the course of many thousands of years, has led to the glorious triumph of the human mind over its lower animal ancestral stages. Here, as everywhere, the only way to arrive at a knowledge of natural truth is to compare kindred phenomena, and investigate their development. Hence we must above all, as we did in the examination of the bodily development, compare the highest animal phenomena on the one hand with the lowest animal phenomena, and on the other with the lowest human phenomena. The final result of this comparison is this—that *between the most highly developed animal souls, and the lowest developed human souls, there exists only a small quantitative, but no qualitative difference*, and that this difference is much less than the difference between the lowest and the highest human souls, or than the difference between the highest and the lowest animal souls.

In order to be convinced of this important result, it is above all things necessary to study and compare the mental

life of wild savages and of children.³² At the lowest stage of human mental development are the Australians, some tribes of the Polynesians, and the Bushmen, Hottentots, and some of the Negro tribes. Language, the chief characteristic of genuine men, has with them remained at the lowest stage of development, and hence also their formation of ideas has remained at a low stage. Many of these wild tribes have not even a name for animal, plant, colour, and such most simple ideas, whereas they have a word for every single, striking *form* of animal and plant, and for every single sound or colour. Thus even the most simple abstractions are wanting. In many of these languages there are numerals only for one, two, and three: no Australian language counts beyond four. Very many wild tribes can count no further than ten or twenty, whereas some very clever dogs have been made to count up to forty and even beyond sixty. And yet the faculty of appreciating number is the beginning of mathematics! Nothing, however, is perhaps more remarkable in this respect, than that some of the wildest tribes in southern Asia and eastern Africa have no trace whatever of the first foundations of all human civilization, of family life, and marriage. They live together in herds, like apes, generally climbing on trees and eating fruits; they do not know of fire, and use stones and clubs as weapons, just like the higher apes. All attempts to introduce civilization among these, and many of the other tribes of the lowest human species, have hitherto been of no avail; it is impossible to implant human culture where the requisite soil, namely, the perfecting of the brain, is wanting. Not one of these tribes has ever been ennobled by civilization; it rather accelerates their extinction.

They have barely risen above the lowest stage of transition from man-like apes to ape-like men, a stage which the progenitors of the higher human species had already passed through thousands of years ago.⁴⁴

Now consider, on the other hand, the highest stages of development of mental life in the higher vertebrate animals, especially birds and mammals. If, as is usually done, we divide the different emotions of the soul into three principal groups—sensation, will, and thought—we shall find in regard to every one of them, that the most highly developed birds and mammals are on a level with the lowest human beings, or even decidedly surpass them. The *will* is as distinctly and strongly developed in higher animals as in men of character. In both cases it is never actually free, but always determined by a causal chain of ideas. (Compare vol. i. p. 237.) In like manner, the different degrees of will, energy, and passion are as variously graduated in higher animals as in man. The *affections* of the higher animals are not less tender and warm than those of man. The fidelity and devotion of the dog, the maternal love of the lioness, the conjugal love and connubial fidelity of doves and love-birds are proverbial, and might serve as examples to many men. If these virtues are to be called “instincts,” then they deserve the same name in mankind. Lastly, with regard to *thought*, the comparative consideration of which doubtless presents the most difficulties, this much may with certainty be inferred—especially from an examination of the comparative psychology of cultivated domestic animals—that the processes of thinking, here follow the same laws as in ourselves. Experiences everywhere form the foundation of conceptions, and lead to the

recognition of the connection between cause and effect. In all cases, as in man, it is the path of induction and deduction which leads to the formation of conclusions. It is evident that in all these respects the most highly developed animals stand much nearer to man than to the lower animals, although they are also connected with the latter by a chain of gradual and intermediate stages. In Wundt's excellent "Lectures on the Human and Animal Soul,"⁴⁶ there are a number of proofs of this.

Now, if instituting comparisons in both directions, we place the lowest and most ape-like men (the Austral Negroes, Bushmen, and Andamans, etc.), on the one hand, together with the most highly developed animals, for instance, with apes, dogs, and elephants, and on the other hand, with the most highly developed men—Aristotle, Newton, Spinoza, Kant, Lamarck, or Goethe—we can then no longer consider the assertion, that the mental life of the higher mammals has gradually developed up to that of man, as in any way exaggerated. If one must draw a sharp boundary between them, it has to be drawn between the most highly developed and civilized man on the one hand, and the rudest savages on the other, and the latter have to be classed with the animals. This is, in fact, the opinion of many travellers, who have long watched the lowest human races in their native countries. Thus, for example, a great English traveller, who lived for a considerable time on the west coast of Africa, says: "I consider the negro to be a lower species of man, and cannot make up my mind to look upon him as 'a man and a brother,' for the gorilla would then also have to be admitted into the family." Even many Christian missionaries, who, after

long years of fruitless endeavours to civilize these lowest races, have abandoned the attempt, express the same harsh judgment, and maintain that it would be easier to train the most intelligent domestic animals to a moral and civilized life, than these unreasoning brute-like men. For instance, the able Austrian missionary Morlang, who tried for many years without the slightest success to civilize the ape-like negro tribes on the Upper Nile, expressly says: "that any mission to such savages is absolutely useless. They stand far below unreasoning animals; the latter at least show signs of affection towards those who are kind towards them, whereas these brutal natives are utterly incapable of any feeling of gratitude."

Now, it clearly follows from these and other testimonies, that the mental differences between the lowest men and the animals are less than those between the lowest and the highest men; and if, together with this, we take into consideration the fact that in every single human child mental life develops slowly, gradually, and step by step, from the lowest condition of animal unconsciousness, need we still feel offended when told that the mind of the whole human race has in like manner gone through a process of slow, gradual, and historical development? Can we find it "degrading" to the human soul that, by a long and slow process of differentiation and perfecting, it has very gradually developed out of the soul of vertebrate animals? I freely acknowledge that this objection, which is at present raised by many against the pithecoïd theory, is quite incomprehensible to me. On this point Bernhard Cotta, in his excellent "*Geologie der Gegenwart*," very justly remarks: "Our ancestors may be a great honour to us; but it is much better if we are an honour to them!"⁸¹

Our Theory of Development explains the origin of man and the course of his historical development in the only natural manner. We see in his gradually ascensive development out of the lower vertebrata, the greatest triumph of humanity over the whole of the rest of Nature. We are proud of having so immensely outstripped our lower animal ancestors, and derive from it the consoling assurance that in future also, mankind, as a whole, will follow the glorious career of progressive development, and attain a still higher degree of mental perfection. When viewed in this light, the Theory of Descent as applied to man opens up the most encouraging prospects for the future, and frees us from all those anxious fears which have been the scarecrows of our opponents.

We can even now foresee with certainty that the complete victory of our Theory of Development will bear immensely rich fruits—fruits which have no equal in the whole history of the civilization of mankind. Its first and most direct result—the complete reform of *Biology*—will necessarily be followed by a still more important and fruitful reform of *Anthropology*. From this new theory of man there will be developed a new *philosophy*, not like most of the airy systems of metaphysical speculation hitherto prevalent, but one founded upon the solid ground of Comparative Zoology. A beginning of this has already been made by the great English philosopher Herbert Spencer.⁴⁵ Just as this new monistic philosophy first opens up to us a true understanding of the real universe, so its application to practical human life must open up a new road towards moral perfection. By its aid we shall at last begin to raise ourselves out of the state of social barbarism in

which, notwithstanding the much vaunted civilization of our century, we are still plunged. For, unfortunately, it is only too true, as Alfred Wallace remarks with regard to this, at the end of his book of travels: "Compared with our wondrous progress in physical science and its practical applications, our system of government, of administering justice, of national education, and our whole social and moral organisation remains in a state of barbarism."

This social and moral barbarism we shall never overcome by the artificial and perverse training, the one-sided and defective teaching, the inner untruth and the external tinsel, of our present state of civilization. It is above all things necessary to make a complete and honest return to Nature and to natural relations. This return, however, will only become possible when man sees and understands his true "place in nature." He will then, as Fritz Ratzel has excellently remarked,⁴⁷ "no longer consider himself an *exception* to natural laws, but begin to seek for what is lawful in his own actions and thoughts, and endeavour to lead a life *according* to natural laws." He will come to arrange his life with his fellow-creatures—that is, the family and the state—not according to the laws of distant centuries, but according to the rational principles deduced from knowledge of nature. Politics, morals, and the principles of justice, which are still drawn from all possible sources, will have to be formed in accordance with natural laws only. An *existence worthy of man*, which has been talked of for thousands of years, will at length become a reality.

The highest function of the human mind is perfect knowledge, fully developed consciousness, and the moral activity arising from it. "Know thyself!" was the cry of the philo-

sophers of antiquity to their fellow-men who were striving to ennoble themselves. "Know thyself!" is the cry of the Theory of Development, not merely to the individual, but to all mankind. And whilst increased knowledge of self becomes, in the case of every individual man, a strong force urging to an increased attention to conduct, mankind as a whole will be led to a higher path of moral perfection by the knowledge of its true origin and its actual position in Nature. The simple religion of Nature, which grows from a true knowledge of Her, and of Her inexhaustible store of revelations, will in future ennoble and perfect the development of mankind far beyond that degree which can possibly be attained under the influence of the multifarious religions of the churches of the various nations,—religions resting on a blind belief in the vague secrets and mythical revelations of a sacerdotal caste. Future centuries will celebrate our age, which was occupied with laying the foundations of the Doctrine of Descent, as the new era in which began a period of human development, rich in blessings,—a period which was characterized by the victory of free inquiry over the despotism of authority, and by the powerful ennobling influence of the Monistic Philosophy.

LIST OF THE WORKS REFERRED TO IN THE
TEXT BY FIGURES, THUS—⁽¹⁾,

The study of which is recommended to the Reader.

1. *Charles Darwin*, On the Origin of Species by means of Natural Selection; or, the Preservation of Favoured Races in the Struggle for Life. London, 1859. 5th Edition, 1869.

2. *Jean Lamarck*, Philosophie Zoologique, ou Exposition des Considérations relatives à l'histoire naturelle des animaux; à la diversité de leur organisation et des facultés, qu'ils en obtiennent; aux causes physiques, qui maintiennent en eux la vie et donnent lieu aux mouvemens, qu'ils exécutent; enfin, à celles qui produisent, les unes le sentiment, et les autres l'intelligence de ceux qui en sont doués. 2 Tomes. Paris, 1809.

3. *Wolfgang Goethe*, Zur Morphologie: Bildung und Umbildung organischer Naturen. Die Metamorphose der Pflanzen, 1790. Osteologie, 1786. Vorträge über die drei ersten Capitel des Entwurfs einer allgemeinen Einleitung in die vergleichende Anatomie, ausgehend von der Osteologie, 1786. Zur Naturwissenschaft im Allgemeinen, 1780-1832.

(*Wolfgang Goethe*, Contributions to Morphology: Formation and Transformation of Organic Natures. The Metamorphosis of Plants, 1790. Osteology, 1786. Lectures on the first three chapters of an Attempt at a General Introduction to Comparative Anatomy, beginning with Osteology, 1786. Contributions to the Science of Nature in general, 1780-1832.)

4. *Ernst Haeckel*, Generelle Morphologie der Organismen : Allgemeine Grundzüge der organischen Formenwissenschaft, mechanisch begründet durch die von Charles Darwin reformirte Descendenz-theorie. I. Band, Allgemeine Anatomie der Organismen, oder Wissenschaft von den entwickelten organischen Formen. II. Band, Allgemeine Entwicklungsgeschichte der Organismen, oder Wissenschaft von den entstehenden organischen Formen. Berlin, 1866.

(Ernst Haeckel, General Morphology of Organisms ; General Outlines of the Science of Organic Forms based on Mechanical Principles through the Theory of Descent as reformed by Charles Darwin. Vol. I., General Anatomy of Organisms ; or, the Science of Fully Developed Organic Forms. Vol. II., General History of the Development of Organisms ; or, the Science of Organic Forms in their Origin. Berlin, 1866.)

5. *Louis Agassiz*, An Essay on Classification. Contributions to the Natural History of the United States. Boston. Vol. I., 1857.

6. *August Schleicher*, Die Darwin'sche Theorie und die Sprachwissenschaft. Weimar, 1863.

(August Schleicher, Darwin's Theory and the Science of Language. Weimar, 1863.)

7. *M. J. Schleiden*, Grundzüge der wissenschaftlichen Botanik (die Botanik als inductive Wissenschaft). 2 Bände. Leipzig, 1849.

(M. J. Schleiden, Principles of Scientific Botany (Botany as an Inductive Science). 2 Vols. Leipzig, 1849. Translated by Edwin Lankester, M.D., F.R.S. London, 1849.)

8. *Franz Unger*, Versuch einer Geschichte der Pflanzenwelt. Wien, 1852.

(Franz Unger, Essay on the History of the Vegetable Kingdom. Vienna, 1852.)

9. *Victor Carus*, System der thierischen Morphologie. Leipzig, 1853.

(Victor Carus, System of Animal Morphology. Leipzig, 1853.)

10. *Louis Büchner*, Kraft und Stoff. Empirisch-naturphilosophische Studien in allgemein verständlicher Darstellung Frankfurt, 1855, 3 Auflage. 1867, 9 Auflage.

(Louis Büchner, Force and Matter. Studies in the Empirical Philosophy of Nature, treated popularly. Frankfurt, 1855, 3rd Edition. 1867, 9th Edition.)

11. *Charles Lyell*, Principles of Geology. London, 1830. 10th Edition, 1868.

12. *Albert Lange*, Geschichte des Materialismus und Kritik seiner Bedeutung in der Gegenwart. Iserlohn, 1866.

(Albert Lange, History of Materialism, and a Criticism of its Importance at the Present Time. Iserlohn, 1866.)

13. *Charles Darwin*, Voyage of the *Beagle*. London.

14. *Charles Darwin*, The Variation of Animals and Plants under Domestication. 2 Vols. London, 1868.

15. *Ernst Haeckel*, Studien über Moneren und andere Protisten, nebst einer Rede über Entwicklungsgang und Aufgabe der Zoologie. Mit 6 Kupfertafeln. Leipzig, 1870.

(Ernst Haeckel, Studies on the Monera and other Protista, together with a Discourse on the Evolution and the Problems of Zoology. With 6 Copper-plates. Leipzig, 1870.)

16. *Fritz Müller*, Für Darwin. Leipzig, 1864.

(Fritz Müller, For Darwin. Translated by W. S. Dallas. London, Murray.)

17. *Thomas Huxley*, On our Knowledge of the Causes of the Phenomena of Organic Nature. Six Popular Lectures. London, Hardwicke, 1862.

18. *H. G. Brönn*, Morphologische Studien über die Gestaltungsgesetze der Naturkörper überhaupt, und der Organischen insbesondere. Leipzig und Heidelberg, 1858.

(*H. G. Brönn*, Morphological Studies on the Laws of Form of Natural Bodies in General, and of Organic Bodies in Particular. Leipzig and Heidelberg, 1858.)

19. *H. G. Brönn*, Untersuchungen über die Entwicklungsgesetze der organischen Welt während der Bildungszeit unserer Erdoberfläche. Stuttgart, 1858.

(*H. G. Brönn*, Investigations on the Laws of Development of the Organic World during the Time of the Formation of the Earth's Crust. Stuttgart, 1858.)

20. *Carl Ernst Bär*, Ueber Entwicklungsgeschichte der Thiere. Beobachtung und Reflexion. 2 Bände. 1828.

(*Carl Ernst Bär*, On the History of the Development of Animals. Observation and Reflection. 2 Vols. 1828.)

21. *Carl Gegenbaur*, Grundzüge der vergleichenden Anatomie. Leipzig, 1859. 2 (Umgearbeitete) Auflage, 1870.

(*Carl Gegenbaur*, Outlines of Comparative Anatomy. Leipzig, 1859. 2nd (Revised) Edition, 1870.)

22. *Immanuel Kant*, Allgemeine Naturgeschichte und Theorie des Himmels, oder Versuch von der Verfassung und dem mechanischen Ursprunge des ganzen Weltgebäudes nach Newton'schen Grundsätzen abgehandelt. Königsberg, 1755.

(*Immanuel Kant*, General History of Nature and Theory of the Heavens; or, Essay on the Constitution and the Mechanical Origin of the whole Universe treated according to Newton's Principles. Königsberg, 1755.)

23. *Ernst Haeckel*, Die Radiolarien. Eine Monographie. Mit einem Atlas von 35 Kupfertafeln. Berlin, 1862.

(*Ernst Haeckel*, The Radiolaria. A Monograph, with Atlas containing 35 Copper-plates. Berlin, 1862.)

24. *August Weismann*, Ueber den Einfluss der Isolirung auf die Artbildung. Leipzig, 1872.

(August Weismann, On the Influence of Isolation on the Formation of Species. Leipzig, 1872.)

25. *Ernst Haeckel*, Ueber die Entstehung und den Stammbaum des Menschengeschlechts. Zwei Vorträge in der Sammlung gemeinverständlicher wissenschaftlicher Vorträge, herausgegeben von Virchow und Holtzendorff. Berlin, 1868. 2 Auflage, 1870.

(Ernst Haeckel, On the Origin and the Pedigree of the Human Race. Two Lectures in the Collection of Popular Scientific Lectures, edited by Virchow and Holtzendorff. Berlin, 1868. 2nd Edition, 1870.)

26. *Thomas Huxley*, Evidences as to Man's Place in Nature. Three Parts: 1. On the Natural History of the Man-like Apes. 2. On the Relations of Man to the Lower Animals. 3. On some Fossil Remains of Man. London, Williams & Norgate.

27. *Carl Vogt*, Vorlesungen über den Menschen, seine Stellung in der Schöpfung und in der Geschichte der Erde. 2 Bände. Giessen, 1863.

(Carl Vogt, Lectures on Man, his Place in Creation and in the History of the Earth. 2 Vols. Giessen, 1863.)

28. *Friedrich Rolle*, Der Mensch, seine Abstammung und Gesittung im Lichte der Darwin'schen Lehre von der Art-Entstehung, und auf Grund der neueren geologischen Entdeckungen dargestellt. Frankfurt-a-M., 1866.

(Friedrich Rolle, Man, his Derivation and Civilization, in the Light of Darwin's Theory of the Origin of Species, based on Recent Geological Discoveries. Frankfurt-a-M., 1866.)

29. *Eduard Reich*, Die allgemeine Naturlehre des Menschen. Giessen, 1865.

(Eduard Reich, The General Natural History of Man. Giessen, 1865.)

30. *Charles Lyell*, The Antiquity of Man. London, Murray.

31. *Bernhard Cotta*, Die Geologie der Gegenwart. Leipzig, 1866.

(Bernhard Cotta, The Geology of the Present Day.)

32. *Karl Zittel*, Aus der Urzeit. Bilder aus der Schöpfungsgeschichte. München, 1871.

(Karl Zittel, Primæval Times. Pictures from the History of Creation. Munich, 1871.)

33. *C. Radenhausen*, Isis. Der Mensch und die Welt. 4 Bände. Hamburg, 1863. 2 Auflage, 1871.

(C. Radenhausen, Isis. Man and the Universe. 4 Vols. Hamburg, 1863. 2nd Edition, 1871.)

34. *August Schleicher*, Ueber der Bedeutung der Sprache für die Naturgeschichte des Menschen. Weimar, 1865.

(August Schleicher, On the Importance of Language to the Natural History of Man. Weimar, 1865).

35. *Wilhelm Bleek*, Ueber den Ursprung der Sprache. Herausgegeben mit einem Vorwort von Ernst Haeckel. Weimar, 1868.

(Wilhelm Bleek, On the Origin of Language. Edited and with a Preface by Ernst Haeckel. Weimar, 1868.)

36. *Alfred Russel Wallace*, The Malayan Archipelago. London, Macmillan.

37. *Ernst Haeckel*, Ueber Arbeitstheilung in Natur- und Menschenleben. Sammlung gemeinverständlicher wissenschaftlicher Vorträge, herausgegeben von Virchow und Holtzendorff. 4 Serie. 1869. Heft 78.

(Ernst Haeckel, On Differentiation in Nature and in Human Life. A Collection of Popular Scientific Lectures, edited by Virchow and Holtzendorff. 4th Series. 1869. No. 78.)

38. *Hermann Helmholtz*, Populäre wissenschaftliche Vorträge. Braunschweig, 1871.

(Hermann Helmholtz, Popular Scientific Lectures. Brunswick, 1871.)

39. *Alexander Humboldt*, Ansichten der Natur. Stuttgart, 1826.

(Alexander Humboldt, Views of Nature. Stuttgart, 1826.)

40. *Moritz Wagner*, Die Darwin'sche Theorie und das Migrationsgesetz der Organismen. Leipzig, 1868.

(Moritz Wagner, Darwin's Theory and the Law of the Migration of Organisms. Leipzig, 1868.)

41. *Rudolf Virchow*, Vier Reden über Leben und Kranksein. Berlin, 1862.

(Rudolf Virchow, Four Discourses on Life and Disease. Berlin, 1862.)

42. *Friedrich Müller*, Ethnographie (Reise der österreichischen Fregatte Novara. Anthropologischer Theil. 3 Abtheilung). Wien, 1868.

(Friedrich Müller, Ethnography (Voyage of the Austrian Frigate Novara. Anthropological Part. 3rd Part). Vienna, 1868.)

43. *Ludwig Büchner*, Die Stellung des Menschen in der Natur, in Vergangenheit, Gegenwart und Zukunft. Leipzig, 1870.

(Ludwig Büchner, Man's Place in Nature in the Past, the Present, and the Future. Leipzig, 1870.)

44. *John Lubbock*, Prehistoric Times. London, 1867.

45. *Herbert Spencer*, A System of Philosophy. (1. First Principles. 2. Principles of Biology. 3. Principles of Psychology, etc.) London, 1867. 2nd Edition.

46. *Wilhelm Wundt*, Vorlesungen über die Menschen- und Thierseele. Leipzig, 1863.

(*Wilhelm Wundt*, Lectures on the Human and Animal Soul, Leipzig, 1863.)

47. *Fritz Ratzel*, Sein und Werden der organischen Welt. Eine populäre Schöpfungsgeschichte. Leipzig, 1869.

(*Fritz Ratzel*, Nature and Origin of the Organic World. A Popular History of Creation. Leipzig, 1869.)

48. *Charles Darwin*, The Descent of Man, and Selection in Relation to Sex. 2 Vols. London, 1871.

APPENDIX.

EXPLANATION OF THE PLATES.



PLATE FACING TITLE-PAGE.

Developmental History of a Calcareous Sponge (Olynthus). Compare vol. ii. p. 140. The egg of the Olynthus (Fig. 9), which represents the common ancestral form of all Calcareous Sponges, is a simple cell (Fig. 1). From this there arises, by repeated division (Fig. 2), a globular, mulberry-like heap of numerous equi-formal cells (Morula, Fig. 3; vol. ii. p. 125. As the result of the change of these cells into an outer series of clear ciliated cells (Exoderm) and an inner series of dark, non-ciliated cells (Entoderm), the ciliated larva, or Planula, makes its appearance. This is oval in shape, and forms a cavity in its centre (gastric cavity, or primitive stomach, Fig. 6 *g.*), with an opening (mouth-opening, or primitive mouth, Fig. 6 *o*); the wall of the gastric cavity consists of two layers of cells, or germ-layers, the outer ciliated Exoderm (*e*) and the inner non-ciliated Entoderm (*i*). Thus arises the exceedingly important stomach-larva, or Gastrula, which reappears in the most different tribes of animals as a common larval form (Fig. 5, seen from the surface; Fig. 6, in long section. Compare, vol. ii. pp. 126 and 281). After the Gastrula has swum about for some time in the sea, it fastens itself securely to the sea-bottom, loses its outer vibratile processes, or cilia, and changes into the Ascula (Fig. 7, seen from the surface; Fig. 8, in long section; letters as in Fig. 6). This Ascula is the recapitulative form, according to the biogenetic

fundamental law, the common ancestor of all Zoophytes, namely, the Protascus (vol. ii. pp. 129, 133). By the development of pores in the wall of the stomach and of three-rayed calcareous spicules, the Ascula changes into the Olynthus (Fig. 9.) In Fig. 9 a piece is cut out from the stomach-wall of the Olynthus in order to show the inside of the stomachal cavity, and the eggs which are forming on the surface (*g*). From the Olynthus the most various forms of Calcareous Sponges can develop. One of the most remarkable is the Ascometra (Fig. 10), a stock or colony from which different species, and in fact different generic forms, grow (on the left Olynthus, in the middle Nardorus, on the right Soleniscus, etc., etc.). Further details as to these most interesting forms, and their high importance for the Theory of Descent, may be found in my "Monograph of the Calcareous Sponges" (1872), especially in the first volume. (Compare vol. ii. pp. 160, 167).

PLATE I. (*Between pages 184 and 185, Vol. I.*)

History of the Life of the most Simple Organism, a Moneron (Protomyxa aurantiaca). Compare vol. i. p. 184, and vol. ii. p. 53. The plate is a smaller copy of the drawing in my "Monographie der Moneren" (Biologische Studien, 1 Heft, 1870; Taf. 1), of the developmental history of the Protomyxa aurantiaca; I have there also given a detailed description of this remarkable Moneron (p. 11-30). I discovered this most simple organism in January, 1867, during a stay in Lanzarote, one of the Canary Islands; and moreover I found it either adhering to, or creeping about on the white calcareous shells of a small Cephalopod (vol. ii. p. 162), the Spirula Peronii, which float there in masses on the surface of the ocean, or are thrown up on the shore. The Protomyxa aurantiaca is distinguished from the other Monera by the beautiful and bright orange-red colour of its perfectly simple body, which consists merely of primæval slime, or protoplasm. The fully developed Moneron is represented in Figs. 11 and 12, very much enlarged. When it is hungry (Fig. 11), there radiate from the surface of the globular corpuscule

of plasm, quantities of tree-shaped, branching and mobile threads (pseudo-feet, or pseudo-podia), which do not become retiformly connected. When, however, the Moneron eats (Fig. 12), the mucous threads become variously connected, form net-works and enclose the extraneous corpuscule which serves as food, which the threads afterwards draw into the interior of the Protomyxa. Thus in Fig. 12 (above on the right), a silicious and ciliated Whip-swimmer (Peridinium, vol. ii. pp. 51, 57), has just been caught by the extended mucous filaments, and has been drawn into the interior of the mucous globule, in which there already are several half digested silicious infusoria (Tintinoida), and Diatomeæ (Isthmia). Now, when the Protomyxa has eaten and grown sufficiently, it draws in all its mucous filaments (Fig. 15), and contracts into the form of a globule (Fig. 16 and Fig. 1). In this state of repose the globule secretes a simple gelatinous covering (Fig. 2), and after a time subdivides into a large number of small mucous globules (Fig. 3). These soon commence to move, become pear-shaped (Fig. 4), break through the common covering (Fig. 5), and then swim about freely in the ocean by means of a delicate whip-shaped process, like the Flagellata (vol. ii. p. 57, Fig. 11). When they meet a Spirula shell, or any other suitable object, they adhere to it, draw in their whip, and creep slowly about on it by means of form-changing processes (Figs. 6, 7, 8), like Protamoebæ (vol. i. p. 186, vol. ii. p. 52). These small mucous corpuscles take food (Figs. 9, 10), and attain their full grown form (Figs. 11, 12), either by simple growth or by several of them fusing to form a larger protoplasmic mass (Plasmodium, Figs. 13, 14).

PLATES II. AND III. (*Between pages 294 and 295, Vol. I.*)

Germes or Embryos of four different Vertebrate Animals, namely, Tortoise (*A* and *E*), Hen (*B* and *F*), Dog (*C* and *G*), and Man (*D* and *H*). Figs. *A*, *D*, an early stage of development; Figs. *E*, *H*, a later stage. All the eight embryos are represented as seen from the right side, the curved back turned to the left.

Figs. *A* and *B* are seven times enlarged, Figs. *C* and *D* five times, Figs. *E* and *H* four times. Plate II. exhibits the very close blood relationship between birds and reptiles; Plate III. that between man and the other mammals.

PLATE IV. (*Between pages 34 and 35, Vol. II.*)

The Hand, or Fore Foot, of nine different Mammals. This plate is intended to show the importance of Comparative Anatomy to Phylogeny, in as much as it proves how the internal skeleton of the limbs is continually preserved by *inheritance*, although the external form is extremely changed by *adaptation*. The bones of the skeleton of the hand are drawn in white lines on the brown flesh and skin which surrounds them. All the nine hands are represented in the same position, namely the wrist (where the arm would be joined to it) is placed above, whilst the ends of the fingers or toes are turned downwards. The thumb, or the first (large) fore-toe is on the left in every figure; the little finger, or fifth toe is to the right at the edge of the hand. Each hand consists of three parts, namely (i.) the *wrist* (carpus), composed of two cross rows of short bones (at the upper side of the hand); (ii.) the *mid-hand* (metacarpus), composed of five long and strong bones (marked in the centre of the hand by the numbers 1-5); and (iii.) the five *fingers*, or *fore toes* (digiti), every one of which again consists of several (mostly from two to three), *toe-pieces*, or *phalanges*. The hand of *man* (Fig. 1), in regard to its entire formation, stands mid-way between that of the two large human apes, namely, that of the *gorilla* (Fig. 2), and that of the *orang* (Fig. 3). The fore paw of the *dog* (Fig. 4), is more different, and the hand or breast fin of the *seal* (Fig. 5) still more so. The adaptation of the hand to the movement of swimming, and its transformation into a fin for steering, is still more complete in the *dolphin* (Ziphius, Fig. 6). The extended fingers and bones of the central hand here have remained short and strong in the swimming membrane, but they have become extremely long and thin in the *bat* (Fig. 7), where the hand has developed into a wing. The extreme opposite of the latter formation is the hand

of the *mole* (Fig. 8), which has acquired a powerful spade-like form for digging, with fingers which have become extremely short and thick. What is far more like the human hand than these latter forms, is the fore paw of the lowest and most imperfect of all mammals, the Australian *beaked animal* (*Ornithorhynchus*, Fig. 9), which in its whole structure stands nearer to the common, extinct, primary form of mammalia, than any known species. Hence man differs less in the formation of the hand from this common primary form than from the bat, mole, dolphin, seal, and many other mammals.

PLATE V. (*Between pages 84 and 85, Vol. II.*)

Monophyletic, or One-rooted Pedigree of the Vegetable Kingdom, representing the hypothesis of the common derivation of all plants, and the historical development of the different groups of plants during the palæontological periods of the earth's history. The horizontal lines denote the different smaller and larger periods of the organic history of the earth (which are spoken of in vol. ii. p. 14), and during which the strata containing fossils were deposited. The vertical lines separate the different main-classes and classes of the vegetable kingdom from one another. The arboriform and branching lines indicate, in an approximate manner, by their greater or less number and thickness, the greater or less degree of development, differentiation, and perfecting which each class probably attained in each geological period. (Compare vol. ii. pp. 82, 83.)

PLATE VI. (*Between pages 130 and 131, Vol. II.*)

Monophyletic, or One-rooted Pedigree of the Animal Kingdom, representing the *historical growth of the six animal tribes* during the palæontological periods of the organic history of the earth. The horizontal lines *g h*, *i k*, *l m*, and *n o* divide the five large periods of the organic history of the earth one from another. The field *g a b h* comprises the archilithic, the field *i g h k*, the palæolithic, the field *l i k m* the mesolithic, and the field *n l m o*

the cenolithic period. The short, anthropolithic period is indicated by the line *n o.* (Compare vol. ii. p. 14.) The height of the separate fields corresponds with the relative length of the periods indicated by them, as they may approximately be estimated from the relative thickness of the neptunic strata deposited between them. (Compare vol. ii. p. 22.) The archilithic and primordial period alone, during which the Laurentian, Cambrian, and Silurian strata were deposited, was probably considerably longer than the four subsequent periods taken together. (Compare vol. ii. pp. 10, 20). In all probability the two tribes of worms and Zoophytes attained their full development during the mid-primordial period (in the Cambrian system); the star-fishes and molluscs probably somewhat later (in the Silurian system); whereas the articulata and vertebrata are still increasing in variety and perfection.

PLATE VII. (*Between pages 146 and 147, Vol. II.*)

Group of Animal-Trees (Zoophytes, or Cœlenterata) in the Mediterranean. On the upper half of the plate is a swarm of swimming medusæ and ctenophora; on the lower half a few bunches of corals and hydroid polyps adhering to the bottom of the sea. (Compare the system of Zoophytes, vol. ii. p. 132, and on the opposite page their pedigree.) Among the adhering Zoophytes at the bottom of the ocean there is, below on the right hand, a large coral-colony (1), which is closely akin to the red precious coral (*Eucorallium*), and like the latter belongs to the group of corals with eight rays (*Octocoralla Gorgonida*); the single individuals (or persons) of the branching stock have the form of a star with eight rays, consisting of eight tentacles, which surround the mouth. (*Octocoralla*, vol. ii. p. 143). Directly below and in front of it (quite below on the right), is a small bush of hydroid polyps (2), belonging to the group of bell-polyps, or *Campanulariæ* (vol. ii. p. 146). A larger stock of hydroid polyps (3), belonging to the group of tube-polyps, or *Tubulariæ*, rises, to the left, on the opposite side, with its long thin branches. At its base is spread a stock of silicious sponges (*Halichondria*)

(4), with short, finger-shaped branches (vol. ii. p. 139). Behind it, below on the left (5), is a very large marine rose (*Actinia*), a single individual from the class of six-rayed corals (*Hexacoralla*, vol. ii. p. 143). Its low, cylindrical body has a crown of very numerous and large leaf-shaped tentacles. Below, in the centre of the ground (6), is a sea-anemone (*Cereanthus*) from the group of four-fold corals (*Tetracoralla*). Lastly, on a small hill on the bottom of the sea, there rises, on the right above the corals (1) a cup-polyp (*Lucernaria*), as the representative of the stalked-jellies. (*Podactinaria*, or *Calycozoa*, vol. ii. p. 144.) Its cup-shaped, stalked body (7) has eight globular clusters of small, knotted tentacles on its rim.

Among the *swimming Zoophytes* which occupy the upper half of Plate VII., the hydromedusæ are especially remarkable, on account of their alteration of generation. (Compare vol. i. p. 206). Directly above the *Lucernaria* (7) floats a small tiara jelly (*Oceania*), whose bell-shaped body has a process like a dome, the form of a papal tiara (8). From the opening of the bell there hangs a wreath of very fine and long tentacles. This *Oceania* is the offspring of a tube-polyp, resembling the adhering *Tubularia* below on the left (3). Beside this latter, on the left, swims a large but very delicate hair-jelly (*Æquorea*). Its disc-shaped, slightly arched body is just drawing itself together, and pressing water out of the cavity of the cup lying below (9). The numerous, long, and fine hair-like tentacles which hang down from the rim of the cup are drawn by the ejected water into a conical bunch, which towards the centre turns upwards like a collar, and is thrown into folds. Above, in the middle of the cavity of the cup, hangs the stomach, the mouth of which is surrounded by four lobes. This *Æquorea* is derived from a small bell-polyp, resembling the *Campanularia* (2). The small, slightly arched cap-jelly (*Eucopa*), swimming above in the centre (10), is likewise derived from a similar bell-polyp. In these three last cases (8, 9, 10), as in the majority of the hydromedusæ, the alternation of generation consists in the freely swimming medusa (8, 9, 10), arising by the formation of buds (therefore by non-

sexual generation, vol. i. p. 192), from adhering hydroid polyps (2, 3). These latter, however, originate out of the fructified eggs of the medusæ (therefore by sexual generation, vol. i. p. 195). Hence the non-sexual, adhering generation of polyps (I., III., V., etc.) regularly alternates with the sexual, freely swimming generation of medusæ (II., IV., VI., etc.) This alteration of generation can only be explained by the Theory of Descent.

The same remark applies to a kindred form of propagation, which is still more remarkable, and which I discovered in 1864, near Nice, in the Elephant-jellies (Geryonida), and called *allœogony*, or *allœogenesis*. In this case two completely distinct forms of medusa are descended from one another; the larger and more highly developed generation (11), Geryonia, or Carmarina, is six-rayed, with six foliated sexual organs, and six very movable marginal filaments. From the centre of its bell-shaped cup, like the tongue of a bell, hangs a long proboscis, at the end of which is the opening of the mouth and stomach. In the cavity of the stomach is a long, tongue-shaped bunch of buds (which on Plate VII. (n) is extended from the mouth on the left like a tongue). On this tongue, when the Geryonia is sexually ripe, there bud a number of small medusæ. They are, however, not Geryoniæ, but belong to an entirely distinct but very different form of medusa, namely, to the genus Cunina, of the family of the *Æginida*. This Cunina (12) is very differently constructed; it has a flat, semi-globular cup without proboscis, consists in early life of six divisions, later of sixteen, and has sixteen bag-shaped sexual organs, and sixteen short, stiff, and strongly curved tentacles. A further explanation of this wonderful allœogenesis may be found in my "Contributions to the Natural History of the Hydromedusæ." (*Leipzig*, Englemann, 1865), the first part of which contains a monograph of the Elephant-jellies, or Geryonida, illustrated by six copper-plates.

Even more interesting and instructive than these remarkable relations are the vital phenomena of the *Siphonophora*, whose wonderful polymorphism I have frequently spoken of, and described in a popular manner in my lecture on "Differentia-

tion in Nature and Human Life.”³⁷ (Compare vol. i. p. 270, and vol. ii. p. 140). An example of this is given in Plate VII. in the drawing of the beautiful Physophora (13). This swimming stock or colony of hydromedusæ is kept floating on the surface of the sea by a small swimming bladder filled with air, which in the drawing is seen rising above the surface of the water. Below it is a column of four pairs of swimming bells, which eject water, and thereby set the whole colony in motion. At the lower end of the column of swimming bells is a crown-shaped wreath of curved spindle-shaped *sensitive polyps*, which also serve as a covering, under the protection of which the other individuals of the stock (the eating, catching, and reproductive persons) are hidden. The *ontogenesis* of the Siphonophora (and especially of this Physophora), I first observed in Lanzerote, one of the Canary Islands, in 1866, and described in my “History of the Development of the Siphonophora,” and added fourteen plates for its explanation. (Utrecht, 1869). It is rich in interesting facts, which can only be explained by the Theory of Descent.

Another circumstance, which is also only explicable by the Theory of Descent, is the remarkable change of generation in the higher medusæ, the disc-jellies (Discomedusæ, vol. ii. p. 136), a representative of which is given at the top of Plate VII., in the centre (rather in the back ground), namely, a Pelagia (14). From the bottom of the bell-shaped cup, which is strongly arched and the rim of which is neatly indented, there hang four very long and strong arms. The non-sexual polyps, from which these disc-jellies are derived, are exceedingly simple primæval polyps, differing very little from the common fresh-water polyp (Hydra). The alternation of generation in these Discomedusæ has also been described in my lecture on Differentiation,³⁷ and there illustrated by the Aurelia by way of example.

Finally, the last class of Zoophytes, the group of comb-jellies (Ctenophora, vol. ii. p. 142), has two representatives on Plate VII. To the left, in the centre, between the *Æquorea* (9), the Physophora (13), and the Cunina (12), is a long and thin band like a belt (15), winding like a snake; this is the large and

splendid *Venus' girdle* of the Mediterranean (Cestum), the colours of which are as varied as those of the rainbow. The actual body of the animal, which lies in the centre of the long belt, is very small, and constructed exactly like that of the *melon-jelly* (Cydippe), which floats above to the left (16). On the latter are visible the eight characteristic fringed bands, or ciliated combs, of the ctenophora, and also two long tentacles which extend right across the page, and are fringed with still finer threads.

PLATES VIII. AND IX. (*Between pages 170 and 171, Vol. II.*)

History of the Development of Star-fishes (Echinoderma, or Estrella). The two plates exhibit their alternation of generation (vol. ii. p. 168), with an example from each of the four classes of Star-fishes. The sea-stars (Asterida) are represented by Uraster (*A*), the sea-lilies (Crinoida) by Comatula (*B*), the sea-urchins (Echinida) by Echinus (*C*), and finally, the sea-cucumbers (Holothuriæ) by Synapta (*D*). (Compare vol. ii. pp. 166 and 176). The successive stages of development are marked by the numbers 1-6.

Plate VIII. represents the individual development of the first and non-sexual generation of Star-fishes, that is, of the *nurses* (usually, but erroneously, called larvæ). These nurses possess the form-value of a simple, unsegmented worm-individual. Fig 1 represents the egg of the four Star-fishes; and it, in all essential points, agrees with that of man and of other animals. (Compare vol. i. p. 297, Fig. 5.) As in man, the protoplasm of the egg-cell (the yolk) is surrounded by a thick, structureless membrane (zona pellucida), and contains a globular, cell-kernel (nucleus), as clear as glass, which again encloses a nucleolus. Out of the fertilised egg of the Star-fish (Fig. *A* 1) there develops in the first place, by the repeated sub-division of cells, a globular mass of homogeneous cells (Fig. 6, vol. i. p. 299), and this changes into a very simple nurse, which has almost the same shape as a wooden shoe (Fig. *A* 2—*D* 2). The edge of the opening of the shoe is bordered by a fringe of cilia, the ciliary movements of

which keep the microscopically small and transparent nurse swimming about freely in the sea. This fringe of cilia is marked in Fig *A 2—A 4*, on Plate VII., by the narrow alternately light and dark seam. The nurse then, in the first place, forms a perfectly simple intestinal canal for nutrition, mouth (*o*), stomach (*m*), and anus (*a*). Later, the windings of the fringe of cilia become more complicated, and there arise arm-like processes (Fig. *A 3—D 3*). In sea-stars (*A 4*) and sea-urchins (*C 4*) these arm-like processes, which are fringed with cilia, afterwards become very long. But in the case of sea-lilies (*B 3*) and sea-cucumbers (*D 4*), instead of this, the fringe of cilia, which at first, through winding in and out, forms one closed ring, changes subsequently into a succession of separate ciliated girdles, one lying behind the other.

In the interior of this curious nurse there then develops, by a non-sexual process of generation, namely, by the formation of internal buds or germ-buds (round about the stomach), the second generation of Star-fishes, which later on become sexually ripe. This second generation, which is represented on Plate IX. in a fully developed condition, exists originally as a stock or cormus of five worms, connected at one end in the form of a star, as is most clearly seen in the sea-stars, the most ancient and original form of the star-fishes. The second generation, which grows at the expense of the first, appropriates only the stomach and a small portion of the other organs of the latter, but forms for itself a new mouth and anus. The fringe of cilia, and the other parts of the body of the nurse, afterwards disappear. The second generation (*A 5—D 5*), is at first smaller or not much larger than the nurse, whereas, by growth, it afterwards becomes more than a hundred times, or even a thousand times, as large. If the ontogeny of the typical representatives of the four classes of Star-fishes be compared, it is easily seen that the original kind of development has been best preserved in sea-stars (*A*) and sea-urchins (*C*) by inheritance, whereas in sea-lilies (*B*) and sea-cucumbers it has been suppressed according to the laws of abbreviated inheritance (vol. i. p. 212).

Plate IX. shows the fully developed and sexually mature animals of the second generation from the mouth side, which, in the natural position of Star-fishes (when creeping at the bottom of the sea), in sea-stars (*A 6*) and sea-urchins (*C 6*), is below, in sea-lilies (*B 6*) above, and in sea-cucumbers (*D 6*) in front. In the centre we perceive, in all the four Star-fishes, the star-shaped, five-pointed opening of the mouth. In sea-stars, from each arm there extend several rows of little sucking feet, from the centre of the under-side of each arm to the end. In sea-lilies (*B 6*), each arm is split and feather-like from its base upwards. In sea-urchins (*C 6*) the five rows of sucking feet are divided by broader fields of spines. In sea-cucumbers, lastly (*D 6*), on the worm-like body it is sometimes only the five rows of little feet, sometimes only the feathery tentacles surrounding the mouth, from five to fifteen (in this case ten), that are externally visible.

(PLATES X. AND XI. (*Between pages 174 and 175, Vol. II.*))

Historical Development of the Crab-fish (Crustacea).—The two plates illustrate the development of the different Crustacea from the nauplius, their common primæval form. On Plate XI. six Crustacea, from six different orders, are represented in a fully developed state, whereas on Plate X. the early nauplius stages are given. From the essential agreement between the latter we may, on the ground of the fundamental law of biogeny, with full assurance maintain the derivation of the different Crustacea from a single, common primary form, a long since extinct Nauplius, as was first shown by Fritz Müller in his excellent work "Für Darwin."¹⁶

Plate X. represents the *early nauplius stages* from the ventral side, so that the three pairs of legs, on the short, three-jointed trunk are distinctly visible. The first of these pairs of legs is simple and unsegmented, whereas the second and third pairs are forked. All three pairs are furnished with stiff bristles, which, through the paddling motion of the legs, serve as an apparatus for swimming. In the centre of the body, the per-

fectly simple, straight intestinal canal is visible, possessing a mouth in front, and an anal orifice behind. In front, above the mouth, lies a simple, single eye. All the six forms of nauplius entirely agree in all these essential characteristics of organization, whereas the six fully developed forms of Crustacea belonging to them, Plate XI., are extremely different in organisation. The differences of the six nauplius forms are confined to quite subordinate and unessential relations in regard to size of body, and the formation of the covering of the skin. If they could be met with in this form in a sexually mature condition, no zoologist would hesitate to regard them as six different species of one genus. (Compare vol. ii. p. 175.)

Plate XI. represents those fully developed and sexually mature forms of Crustacea, as seen from the right side, which have ontogenetically (hence also phylogenetically) developed out of the six kinds of nauplius. Fig. *A c* shows a freely swimming fresh-water crab (*Limnetis brachyurus*) from the order of the Leaf-foot Crabs (Phyllopoda), slightly enlarged. Of all the still living Crustacea, this order, which belongs to the legion of Gill-foot Crabs (Branchiopoda), stands nearest to the original, common primary form of nauplius. The *Limnetis* is enclosed in a bivalved shell, like a mussel. Our drawing (which is copied from Grube) represents the body of a female animal lying in the left shell; the right half of the shell has been removed. In front, behind the eye, we see the two feelers (antennæ), and behind them the twelve leaf-shaped feet of the right side of the body, behind on the back (under the shell), the eggs. Above, in front, the animal is fixed to the shell.

Fig. *B c* represents a common, freely swimming fresh-water crab (*Cyclops quadricornis*) from the order of Oar-legged crabs (Eucopepoda), highly magnified. In front, below the eye, we see the two feelers of the right side, the foremost of which is longer than the hinder one. Behind these are the gills, and then the four paddling legs of the right side. Behind these are the two large egg-sacks, which, in this case, are attached to the end of the hinder part of the body.

Fig. *C c* is a parasitic Oar-legged crab (*Lernæocera esocina*), from the order of fish lice (*Siphonostoma*). These peculiar crabs, which were formerly regarded as worms, have originated, by adaptation to a parasitical life, out of freely swimming, Oar-legged crabs (*Eucopepoda*), and belong to the same legion (*Copepoda*, vol. ii. p. 176). By adhering to the gills on the skin of fish or other crabs, and feeding on the juice of these creatures, they forfeited their eyes, legs, and other organs, and developed into formless, inarticulated sacks, which, on a mere external examination, we should never suppose to be animals. On the ventral side only there exist, in the shape of short, pointed bristles, the last remains of legs which have now almost entirely disappeared. Two of these rudimentary pairs of legs (the third and fourth) are seen in our drawing on the right. Above, on the head, we see thick, shapeless appendages, the lower ones of which are split. In the centre of the body is seen the intestinal canal, which is surrounded by a dark covering of fat. At its posterior end is the ovary, and the cement-glands of the female sexual apparatus. The two large egg-sacks hang externally (as in the Cyclops, Fig. *B*). Our *Lernæocera* is represented in half profile, and is copied from Claus. (Compare Claus, "Die Copepoden-Fauna von Nizza. Ein Beitrag zur Charakteristik der Formen und deren Abänderungen im Sinne Darwins." Marburg, 1866).

Fig. *D c* represents a so-called "duck mussel" (*Lepas anatifera*), from the order of the Barnacle crabs (*Cirripedia*). These crabs, upon which Darwin has written a very careful monograph, are, like mussels, enclosed in a bivalved, calcareous case, and hence were formerly (even by Cuvier) universally regarded as a kind of mussel, or mollusc. It was only from a knowledge of their ontogeny, and their early nauplius form (*D n*, Plate VIII.), that their crustacean nature was proved. Our drawing shows a "duck mussel" of the natural size, from the right side. The right half of the bivalved shell has been removed, so that the body is seen lying in the left half of the shell. From the rudimentary head of the *Lepas* there issues a long, fleshy

stalk (curving upwards in our drawing); by means of it the Barnacle crab grows on rocks, ships, etc. On the ventral side are six pairs of feet. Every foot is forked and divided into two long, curved, or curled "tendrils" furnished with bristles. Above and behind the last pair of feet projects the thin cylindrical tail.

Fig. *E c* represents a parasitic sack-crab (*Sacculina purpurea*), from the order of Root-crabs (*Rhizocephala*). These parasites, by adaptation to a parasitical life, have developed out of Barnacle crabs (Fig. *D c*), much in the same way as the fish-lice (*C c*), out of the freely swimming Oar-legged crabs (*B c*). However, the suppression, and the subsequent degeneration, of all of the organs, has gone much further in the present case than in most of the fish-lice. Out of the articulated crab, possessing legs, intestine, and eye, and which in an early stage as nauplius (*E n*, Plate VIII.), swam about freely, there has developed a formless, unsegmented sack, a red sausage, which now only contains sexual organs (eggs and sperm) and an intestinal rudiment. The legs and the eye have completely disappeared. At the posterior end is the opening of the genitals. From the mouth grows a thick bunch of numerous tree-shaped and branching root-like fibres. These spread themselves out (like the roots of a plant in the ground) in the soft hinder part of the body of the hermit-crab (*Pagurus*), upon which the root-crab lives as a parasite, and from which it draws its nourishment. Our drawing (*E c*), a copy of Fritz Müller's, is slightly enlarged, and shows the whole of the sausage-shaped sack-crab, with all its root-fibres, when drawn out of the body upon which it lives.

Fig. *F c* is a *shrimp* (*Peneus Mülleri*), from the order of *ten-foot* crabs (*Decapoda*), to which our river cray-fish, and its nearest relative, the lobster, and the short-tailed shore-crabs also belong. This order contains the largest and, gastronomically, the most important crabs, and belongs, together with the mouth-legged and split-legged crabs, to the legion of the stalk-eyed mailed crabs (*Podophthalma*). The shrimp, as well as the river crab, has in front, on each side below the eye, two long feelers (the first

much shorter than the second), then three jaws, and three jaw-feet, then five very long legs (the three fore ones of which, in the Peneus, are furnished with nippers, and the third of which is the longest). Finally, on the first five joints of the hinder part of the body there are other five pairs of feet. This shrimp, which is one of the most highly developed and perfect crabs, originates (according to Fritz Müller's important discovery) out of a nauplius (*F'n* Plate VIII.), and consequently proves that the higher Crustacea have developed out of the same form as the lower ones, namely, the nauplius. (Compare vol. ii. p. 175).

PLATES XII. AND XIII. (*Between pages 200 and 201, Vol. II.*)

Blood relationship between the Vertebrata and the Invertebrata. (Compare vol. ii. pp. 152 and 201.) It is definitely established by Kowalewski's important discovery, which was confirmed by Kupffer, that the ontogeny of the lowest vertebrate animal—the Lancelet, or Amphioxus—agrees in all essential outlines completely with that of the invertebrate Sea-squirts, or Ascidiae, from the class of Sea-sacks, or Tunicata. On our two plates, the ascidia is marked by *A*, the amphioxus by *B*. Plate XIII. represents these two very different animal-forms in a *fully developed* state, as seen from the *left side*, the end of the mouth above, the opposite end below. Hence, in both figures the dorsal side is to the right, the ventral to the left. Both figures are slightly magnified, and the internal organisation of the animals is distinctly visible through the transparent skin. The full-grown ascidia (Fig. *A* 6) grows at the bottom of the ocean, from whence it cannot move, and clings to stones and other objects by means of peculiar roots (*w*) like a plant. The full-grown amphioxus, on the other hand (Fig. *B* 6), swims about freely like a small fish. The letters on both figures indicate the same parts: (*a*) orifice of the mouth; (*b*) orifice of the body, or porus abdominalis; (*c*) dorsal rod, or chorda dorsalis; (*d*) intestine; (*e*) ovary; (*f*) oviduct (same as the sperm-duct); (*g*) spinal marrow; (*h*) heart; (*i*) blind-sac of the intestine; (*k*) gill

basket (respiratory cavity); (*l*) cavity of the body; (*m*) muscles; (*n*) testicle (in the ascidia united with the ovary into a hermaphrodite gland); (*o*) anus; (*p*) genital orifice; (*q*) well-developed embryos in the body cavity of the ascidia; (*r*) rays of the dorsal fin of the amphioxus; (*s*) tail-fin of the amphioxus; (*w*) roots of the ascidia.

Plate XII. shows the *Ontogenesis*, or the individual development of the *Ascidia* (*A*) and the *Amphioxus* (*B*) in five different stages (1-5). Fig. 1 is the egg, a simple cell like the egg of man and all other animals (Fig. *A* 1 the egg of the ascidia, Fig. *B* 1 the egg of the amphioxus). The actual cell-substance, or the protoplasm of the egg-cell (*z*), the so-called yolk, is surrounded by a covering (cell-membrane, or yolk-membrane), and encloses a globular cell-kernel, or nucleus (*y*), the latter, again, contains a kernel-body, or nucleolus (*x*); when the egg begins to develop, the egg-cell first subdivides into two cells. By another sub-division there arise four cells (Fig. *A* 2, *B* 2), and out of these, by repeated sub-division, eight cells (vol. i. p. 190, Fig. 4 *C*, *D*). By fluid gathering in the interior these form a globular bladder bounded by a layer of cells. On one spot of its surface the bladder is turned inwards in the form of a pocket (Fig. *A* 4, *B* 4). This depression is the beginning of the intestine, the cavity (*d* 1) of which opens externally by the provisional larval-mouth (*d* 4). The body-wall, which is at the same time the stomach-wall, now consists of two layers of cells—the germ-layers. The globular larva (Gastrula), now grows in length. Fig. *A* 5 represents the larva of the ascidia, Fig. *B* 5 that of the amphioxus, as seen from the left side in a somewhat more advanced state of development. The orifice of the intestine (*d* 1) has closed. The dorsal side of the intestine (*d* 2) is concave, the ventral side (*d* 3) convex. Above the intestinal tube, on its dorsal side, the neural tube, the beginning of the spinal marrow, is being formed, its cavity still opens externally in front (*g* 2). Between the spinal marrow and the intestine has arisen the spinal rod, or chorda dorsalis (Notochord) (*c*), the axis of the inner skeleton. In the larva of the ascidia this rod (*c*) proceeds

along the long rudder-tail, a larval organ, which is cast off in later transformation. Yet there still exist some very small ascidiæ (Appendicularia) which do not become transformed and attached, but which through life swim about freely in the sea by means of their rudder-tail.

The ontogenetic facts which are systematically represented on Plate XII. and which were first discovered in 1867, deserve the greatest attention, and, indeed, cannot be too highly estimated. They fill up the gap which, according to the opinion of older zoologists existed between the vertebrate and the so-called "invertebrate" animals. This gap was universally regarded as so important and so undeniable, that even eminent zoologists, who were not disinclined to adopt the theory of descent, saw in this gap one of the chief obstacles against it. Now that the ontogeny of the amphioxus and the ascidia has set this obstacle completely aside, we are for the first time enabled to trace the pedigree of man beyond the amphioxus into the many-branching tribe of "invertebrate" worms, from which all the other higher animal tribes have originated.

If our speculative philosophers, instead of occupying themselves with castles in the air, were to give their thoughts for some years to the facts represented on Plates XII. and XIII., as well as to those on Plates II. and III., they would gain a foundation for true philosophy—for the knowledge of the universe firmly based on experience—which would be sure to influence all regions of thought. These facts of ontogenesis are the indestructible foundations upon which the monistic philosophy of future times will erect its imperishable system.

PLATE XIV. (*Between pages 206 and 207, Vol. II.*)

Monophyletic, or One-rooted Pedigree of the Vertebrate Animal tribe, representing the hypothesis of the common derivation of all vertebrate animals, and the historical development of their different classes during the palæontological periods of the earth's history. (Compare Chapter XX. vol. ii. p. 192.) The horizontal

lines indicate the periods (mentioned in vol. ii. p. 14) of the organic history of the earth during which the deposition of the strata containing fossils took place. The vertical lines separate the classes and sub-classes of vertebrata from one another. The tree-shaped and branching lines, by their greater or lesser number and thickness, indicate the approximate degree of development, variety, and perfection, which each class probably attained in each geological period. In those classes which, on account of the soft nature of their bodies, could not leave any fossil remains (which is especially the case with Prochordata, Acrania, Monorrhina, and Dipneusta) the course of development is hypothetically suggested on the ground of arguments derived from the three records of creation—comparative anatomy, ontogeny, and palæontology. The most important starting-points for the hypothetical completion of the palæontological gaps are here, as in all cases, furnished by the *fundamental law of biogeny*, which asserts the inner *causal-nexus existing between ontogeny and phylogeny*. (Compare vol. i. p. 310, and vol. ii. p. 200; also Plates VIII.—XIII.) In all cases we have to regard the individual development (determined by the laws of Inheritance but modified by the laws of Adaptation) as short and quick repetitions of the palæontological development of the tribe. This proposition is the “*ceterum censeo*” of our theory of development.

The statements of the first appearance, or the period of the origin of the individual classes and sub-classes of vertebrate animals (apart from the hypothetical filling in mentioned just now), are taken as strictly as possible from palæontological facts. It must, however, be observed, that in reality the origin of most of the groups probably took place one or two periods earlier than fossils now indicate. In this I agree with Huxley's views; but on Plates V. and XIV. I have disregarded this consideration in order not to go too far from palæontological facts.

The numbers signify as follows (compare also Chapter XX. and vol. ii. pp. 204, 206):—1. Animal Monera; 2. Animal Amœbæ; 3. Community of Amœbæ (Synamœbæ); 4. Ciliated Infusoria without mouths; 5. Ciliated Infusoria with mouths; 6. Gliding

worms (Turbellaria); 7. Sea-sacks (Tunicata); 8. Lancelet (Amphioxus); 9. Hag (Myxinoidea); 10. Lamprey (Petro-myzontia); 11. Unknown forms of transition from single-nostriled animals to primæval fishes; 12. Silurian primæval fish (Onchus, etc.); 13. Living primæval fishes (sharks, rays, Chimæra); 14. Most ancient (Silurian) enamelled fishes (Pteraspis); 15. Turtle fishes (Pamphracti); 16. Sturgeons (Sturiones); 17. Angular-scaled enamelled fishes (Rhombiferi); 18. Bony pike (Lepidosteus); 19. Finny pike (Polypterus); 20. Hollow-boned fishes (Coeloscolopes); 21. Solid boned fishes (Pycnoscolopes); 22. Bald pike (Amia); 23. Primæval boned fishes (Thrissopoda); 24. Bony fishes with air passage to the swimming bladder (Physostomi); 25. Bony fishes without air passage to the swimming bladder (Physoclisti); 26. Unknown forms of transition between primæval fishes and amphibious fishes; 27. Ceratodus; 27*a*. Extinct Ceratodus from the Trias; 27*b*. Living Australian Ceratodus; 28. African amphibious fishes (Protopterus) and American amphibious fishes (Lepidosiren); 29. Unknown forms of transition between primæval fishes and amphibia; 30. Enamelled heads (Ganocephala); 31. Labyrinth toothed (Labyrinthodonta); 32. Blind burrowers (Cæciliæ); 33. Gilled amphibia (Sozobranchia); 34. Tailed amphibia (Sozura); 35. Frog amphibia (Anura); 36. Dichthacantha (Proterosaurus); 37. Unknown forms of transition between Amphibia and Protamnia; 38. Protamnia (common primary form of all Amnion animals); 39. Primary mammals (Promammalia); 40. Primæval reptiles (Proreptilia); 41. (Thecodontia); 42. Primæval dragons (Simosauria); 43. Serpent dragons (Plesiosauria); 44. Fish dragons (Ichthyosauria); 45. Teleosauria (Amphicœla); 46. Steneosauria (Opisthocœla); 47. Alligators and Crocodiles (Prosthocœla); 48. Carnivorous Dinosauria (Harpagosauria); 49. Herbivorous Dinosauria (Therosauria); 50. Mæstricht lizards (Mosasauria); 51. Common primary form of Serpents (Ophidia); 52. Dog-toothed beaked lizards (Cynodontia); 53. Toothless beaked lizards (Cryptodontia); 54. Long-tailed flying lizards (Rhamphorhynchi); 55. Short-tailed

flying lizards (Pterodactyli); 56. Land tortoises (Chersita); 57. Birds—reptiles (Tocornithes), transition form between reptiles and birds; 58. Primæval griffin (Archæopteryx); 59. Water beaked-animal (Ornithorhynchus); 60. Land beaked-animal (Echidna); 61. Unknown forms of transition between Cloacals and Marsupials; 62. Unknown forms of transition between Marsupials and Placentals; 63. Tuft Placentals (Villiplacentalia); 64. Girdle Placentals (Zonoplacentalia); 65. Disc Placentals (Discoplacentalia); 66. Man (Homo pithecogenes, by Linnæus erroneously called, Homo sapiens.)

PLATE XV. (*After page 369, Vol. II.*)

Hypothetical Sketch of the Monophyletic Origin and the Diffusion of the Twelve Species of Men from Lemuria over the earth. The hypothesis here geographically sketched of course only claims an entirely provisional value, as in the present imperfect state of our anthropological knowledge it is simply intended to show how the distribution of the human species, from a single primæval home, may be approximately indicated. The probable primæval home, or "Paradise," is here assumed to be *Lemuria*, a tropical continent at present lying below the level of the Indian Ocean, the former existence of which in the tertiary period seems very probable from numerous facts in animal and vegetable geography. (Compare vol. i. p. 361, and vol. ii. p. 315.) But it is also very possible that the hypothetical "cradle of the human race" lay further to the east (in Hindostan or Further India), or further to the west (in eastern Africa). Future investigations, especially in comparative anthropology and palæontology, will, it is to be hoped, enable us to determine the probable position of the primæval home of man more definitely than it is possible to do at present.

If in opposition to our monophyletic hypothesis, the polyphyletic hypothesis—which maintains the origin of the different human species from several different species of anthropoid ape—be preferred and adopted, then, from among the many possible hypotheses which arise, the one deserving most confidence seems to be

that which assumes a double pithecoïd root for the human race, namely, an Asiatic and an African root. For it is a very remarkable fact, that the African man-like apes (gorilla and chimpanzee) are characterized by a distinctly long-headed, or dolichocephalous, form of skull, like the human species peculiar to Africa (Hottentots, Caffres, Negroes, Nubians). On the other hand, the Asiatic man-like apes (especially the small and large orang), by their distinct, short-headed, or brachycephalous, form of skull agree with human species especially characteristic of Asia (Mongols and Malays). Hence, one might be tempted to derive the latter (the Asiatic man-like apes and primæval men) from a common form of brachycephalous ape, and the former (the African man-like apes and primæval men) from a common dolichocephalous form of ape.

In any case, tropical Africa and southern Asia (and between them Lemuria, which formerly connected them) are those portions of the earth which deserve the first consideration in the discussion as to the primæval home of the human race; America and Australia are, on the other hand, entirely excluded from it. Even Europe (which is in fact but a western peninsula of Asia) is scarcely of any importance in regard to the "Paradise question."

It is self-evident that the migrations of the different human species from their primæval home, and their geographical distribution, could on our Plate XV. be indicated only in a very general way, and in the roughest lines. The numerous migrations of the many branches and tribes in all directions, as well as the very important re-migrations, had to be entirely disregarded. In order to make these latter in some degree clear, our knowledge would, in the first place, need to be much more complete, and secondly, we should have to make use of an atlas with a number of plates showing the various migrations. Our Plate XV. claims no more than to indicate, in a very general way, the approximate geographical dispersion of the twelve human species as it existed in the fifteenth century (before the general diffusion of the Indo-Germanic race), and as it can be sketched out approximately,

so as to harmonize with our hypothesis of descent. The geographical barriers to diffusion (mountains, deserts, rivers, straits, etc.), have not been taken into consideration in this general sketch of migration, because, in earlier periods of the earth's history, they were quite different in size and form from what they are to-day. The gradual transmutation of catarrhine apes into pithecoïd men probably took place in the tertiary period in the hypothetical Lemuria, and the boundaries and forms of the present continents and oceans must then have been completely different from what they are now. Moreover, the mighty influence of the ice period is of great importance in the question of the migration and diffusion of the human species, although it as yet cannot be more accurately defined in detail. I here, therefore, as in my other hypotheses of development, expressly guard myself against any dogmatic interpretation; they are nothing but *first attempts*.

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